FOOD HYGIENE

Wm. CLUNIE HARVEY
AND
HARRY HILL

CFTRI-MYSORE
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Food hygiene..

TLMS

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FAO INTERNATIONAL FOOD TECHNOLOGY TRAINING CENTRE
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FOREWORD

READERS may perhaps wonder why a volume on food hygiene should deal in some detail with the manufacturing aspects of food production, and even with such subjects as food values and nutrition. This has been done deliberately. Food hygiene should concern itself with all these matters. The object of food hygiene is surely to ensure that food is delivered to the consumer in as wholesome and nutritious a state as is practicable. It is for this reason that " Food Hygiene " deals with so many aspects of this vast and vitally important subject. A knowledge of manufacturing methods, and of the constituents of the various types of food consumed in homes, cafés, canteens, restaurants and the like throughout the country, is necessary to a proper understanding of the many hazards which may arise. The authors are of opinion that information of this character should be included, for reference and practical purposes, in any volume which attempts to cover the subject of food hygiene.

It is, of course, admitted that hygiene in its more narrow sense, i.e. personal and collective cleanliness, is a factor which must always receive urgent consideration. This has been duly recognised and is stressed throughout the volume. It must again be emphasised, however, that food poisoning is only one of the results which can follow the faulty manufacture or handling of foodstuffs. The problem goes very much deeper than that and has been dealt with in this light.

At no time in the history of these islands has the need for conserving our food supplies been more clamant. Present-day restrictions demand not only that our food shall be safe, but that its nutritional value shall be maintained at maximum level. The science of food hygiene, properly understood and applied, will help to achieve this very desirable object. The authors hope that the present volume will assist those who are engaged on the supremely important task of securing an improvement in existing standards.

They also wish gratefully to acknowledge the assistance they have received from many interested persons in the preparation of this volume.

W. C. HARVEY.
HARRY HILL.

March, 1952.

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FOOD HYGIENE

CHAPTER I

GENERAL OUTLINE

THE hygienic problems which arise from the manufacture, distribution and handling of foodstuffs are as numerous in their variety as they are important in conception. Since the War, those most intimately concerned with this matter have become more than ever conscious of their responsibilities, and of the urgency which exists for speedy improvement in present methods of food production and distribution. True, some abortive attempts were made to deal with these problems prior to 1939. As an instance, the packaging and wrapping of various articles of food had made some headway when hostilities intervened and brought about a cessation of this very desirable practice, due to shortage of wrapping materials. Members of the general public are intimately concerned with this problem, representing as they do the final consumers of food. Not only do the problems arising from the handling of food affect the general public ; manufacturers, distributors and retailers are involved in what has always been an important public health problem. Epidemics of infectious disease and numerous outbreaks of food poisoning have focussed the attention of the consuming public on the need for clean food. Many of these outbreaks could have been avoided if ordinary care and common sense had been exercised. The population as a whole is well aware that this is so and is ready to appreciate any steps which can be taken to improve conditions of manufacture and distribution. In addition, food is scarce at the present time, due to the after-effects of the War and the rapid growth of the world's population. It behoves all concerned, therefore, to ensure that food is produced properly and protected from contamination of a type likely to cause spoilage and thus affect the consumer. It should perhaps be emphasised that contamination and wastage are not the prerogative of the small trader or of the housewife. There are many large food-producing concerns who could, with advantage, improve their present methods of production and handling with lasting benefit to all concerned.

Sources of Food Supply

Less than 200 years ago the population of these islands relied almost entirely upon the resources of the countryside to provide the food required from day to day. Many families, more particularly those in rural areas, were virtually self-supporting. If by any chance food had to be purchased, it could be obtained from a local supplier, as is still the case in isolated communities. In these circumstances, where the food was of poor quality or was in any way unsatisfactory, the consumer was afforded the opportunity of direct contact with both the producer and the vendor. Improvements were thus possible in many instances. Generally speaking, the adulteration, contamination and pathogenic infection of foodstuffs on the scale now known was not met with in those days. Additions to scientific knowledge, together with better education of the consumer, have radically altered the situation as it stands to-day.

The rapid sprawl of towns, due to the growth of industry and the urbanisation of many villages, led to a demand for foodstuffs which individual localities were unable to supply. This in turn led to collection from a much wider area, and even from abroad. It was possible to supply these new demands by reason of the great improvements which took place in methods of transportation, in conjunction with the development of towns and the concentration of population in selected districts where work was plentiful. In this way food was brought from long distances, even from countries on the other side of the world.

Not only was a greater quantity of food made available ; cheaper and more varied types of food appeared upon the tables of almost every class of society. Refrigeration also became a practical proposition, even in domestic premises, and enabled perishable foodstuffs, particularly meat and meat products, to become available to almost everyone who desired them. Refrigeration also made it possible for foodstuffs to be stored in the home in fresh condition until required for use. With improvements in transport, allied to better methods of cultivation and production at home and abroad, new areas were developed as food-producing units. The products of these areas were carried far and wide and almost entirely abolished the fear of famine which had haunted large areas of the earth's surface. Scientific research developed many new methods of food preservation, which made it possible for food which would otherwise have been perishable to be utilised to the general benefit of the consuming public.

It will be obvious that the problems of hygienic handling of food are aggravated by the variety of sources from which such foodstuffs are obtained. The problem is intensified in these islands owing to the fact that a great deal of our food must of necessity be purchased abroad, in exchange for manufactured goods. Little control can be exercised by the consumer. For this reason the problems which arise are, perhaps, greater than in any other country, having due regard to the standard of life to which we are accustomed.

Commercial Aspect

Owing to the rapid growth of population in this country, with the consequent need for the importation and manufacture of large quantities of food, heavy capital expenditure has been necessary. To this must be added the cost of preparation, distribution and sale of foodstuffs to the final consumers. Food, or its primary ingredients, must be transported to the producing factories in an expeditious manner ; following manufacture it must be distributed to the retail shops with equal speed. Because of this, a specialised food transport service, designed to handle the various materials involved, has been built up over a period of years. This has proved particularly important in relation to perishable foods such as meat, fish and milk. Special types of ships have been devised and built for the transport of meat and fruit over very long distances ; suitable single-purpose vehicles have been developed for use on both road and rail for the satisfactory movement of fish, meat, milk, and for fruit and vegetables. Indeed, the food transport industry is almost comparable in size with that concerned with food production. To a considerable extent the preparation, distribution and sale of foodstuffs are concentrated in the hands of large firms, a state of affairs which has materially assisted in the development of hygienic methods of production and distribution. Unfortunately, this is not invariably the case, as many small traders are still vitally concerned. It is still a fact, however, that only in the case of milk production and distribution has the small trader held his own. Even here the tendency appears to be for amalgamation of a number of small retailers into one large concern which is well provided with capital and able to utilise the most modern scientific developments affecting that particular industry.

Danger to Health

Food, by reason of its composition, may become dangerous following infection by pathogenic bacteria. Food may also be contaminated by the addition of excess preservatives or by other injurious chemical substances, while other forms of adulteration may be practised. The dangers which arise from the consumption of polluted milk, shellfish or ice-cream illustrate this point, but many other types of originally pure food, by reason of mishandling or unsatisfactory storage conditions, may be subject to spoilage which renders them unsuitable, indeed unsafe, for human consumption. Pathogenic bacteria are able to multiply rapidly in certain types of foodstuffs and may be the cause of widespread epidemics of infectious disease or food poisoning. Again, the subtraction of certain essential nutritive elements or the adulteration of food in such a manner as to reduce the nutritive value may rob it of many highly desirable qualities. In certain methods of food processing, poisonous substances are employed as a means of purification. Lack of sufficient care may be followed by the ingestion of undesirable materials which will exert a detrimental effect upon the consumer's health. Lastly, but by no means least, consideration must be given to what might be termed the "cheap and nasty" foods, together with those substitutes which the scarcity of certain articles has brought into prominence. Many such types of foodstuff are the result of competitive pressure by rival firms ; some may even be fraudulent in conception.

Food hygiene, in its widest sense, attempts to prevent or at least minimise such practices. It also aims at preventing good food being spoiled, adulterated or so mishandled as to render it dangerous to the consumer.

Fraudulent Methods

Legal enactments require that, when a consumer purchases any type of food, the article in question must be of the nature, substance and quality demanded. Unfortunately, the number of cases brought into court every year by the various food and drugs authorities prove how often this requirement is eluded. Food is at present far from cheap or plentiful. There is all the more reason, therefore, that, when purchased, food should contain its full nutrient qualities intact and should not be spoiled, contaminated or treated in any way which will prevent this standard being regularly maintained. Although not perhaps a fraudulent practice, too much of our food is at present readily open to *infection*, whether because of the carelessness of those intimately concerned in its manufacture or distribution, or due to reprehensible ignorance of the vital public health principles involved. In far too many instances also diseased food has been wilfully sold with impunity. Not only may infection with undesirable organisms render food dangerous to the health of the consumer ; apart from its public health significance, this may result in avoidable spoilage and subsequent waste. Closely allied to bacterial infection is *contamination* which may occur owing to the introduction of dirt and other extraneous matters, as in the case of unwrapped bread. Contamination from this source may also be the cause of infecting the product at a later stage. *Fraudulent labelling* is yet another frequent means of extracting hard-earned money from the pockets of the unsuspecting public. Rarely a year passes without cases of this type reaching the courts. Possibly the greatest fraud of all, and one to which at present the law closes its eyes, concerns ice-cream. In the majority of cases, what should be a valuable article of food is not the nutritious article which it purports to be and which its name would suggest. Under present conditions of manufacture the article should never be given the name " cream," this being a definite misnomer. Much *treated food* is, in these times of scarcity, sold to the public ; that is, food which is of poor quality but is improved and rendered saleable by cleaning, trimming or by other means. Such treated food finds a ready sale, particularly in the cheaper public markets. This practice, although permissible, cannot be described as in any way desirable. The flagrant *adulteration* of food, either by the addition of unwanted constituents or by the abstraction of some of its nutritive elements in order to reap an increased profit, represents a method which is still all too frequently indulged. The addition of water to milk or the abstraction of some of the butter-fat from the liquid is a case in point. The consumer is also occasionally faced with the addition of dyestuff to food for the purpose of giving the purchaser a false impression as to its quality ; and the use, often quite fraudulently, of poor-quality or unsound ingredients. The fines inflicted upon those detected in these fraudulent practices are rarely sufficient to deter others from following a similar course. Some improvement has, however, occurred in this direction since the War, due to the concerted efforts of the larger local authorities, ably assisted by the Ministry of Food.

Inspectorial Methods

In order that food may be supplied to the public (*a*) in such a condition that no danger to health exists and (*b*) that consumers are not fraudulently deprived of its benefits, the inspection of food and its method of manufacture and distribution has been for many years one of the essential duties imposed upon public health authorities and their officials. In the past the officers appointed to undertake these duties were not always sufficiently well versed in the hygienic requirements of the food trade to carry out this vital task on behalf of the consuming public, which had neither the time nor the requisite knowledge to afford themselves protection. The main efforts of the controlling officials were concentrated upon the supervision of meat, fish and milk, whilst many other equally important foodstuffs were either ignored or received inadequate consideration. An exception might perhaps be made in connection with food and drugs sampling, although, in all but the large towns, this duty was often sadly neglected. Indeed, as regards food and drugs sampling, an index of the approach of those charged with the duty of administration might be evidenced by the use of members of the police force to deal with what is, in fact, an important public health concern. In many cases the responsible official found himself dealing with unscrupulous or ignorant traders, many of whom considered that they were perfectly in order in producing or selling diseased, impure or adulterated foodstuffs, and took speedy exception to any attempt to control their undesirable activities. As has already been stated, however, there was also a marked lack of scientific knowledge on the part of those concerned with supervision. Similar knowledge was equally lacking on the part of many individuals and concerns responsible for the manufacture and distribution of food. Such individuals and firms were too often inclined to look upon food inspectors as necessary evils, to be outwitted whenever possible.

This former " policeman " attitude on the part of controlling officials has now almost entirely passed, a new outlook having taken its place. The mass of food legislation formulated during the years between the wars has been primarily responsible for this change, coupled with the constitution of the Ministry of Food in 1939. The advent of these far-reaching and more precise control measures produced other effects, to which later reference will be made, in addition to providing a means whereby pressure could be exerted upon offenders. Concurrent with expanding legislation came new advances in scientific knowledge of food technology, which assisted both the progressive manufacturer and distributor to provide more and better-quality foodstuffs. In point of fact, legislation affecting the food supply was often opposed by many of the trade interests involved. Generally speaking, however, the changes were accepted in good part, a real attempt being made to improve conditions of manufacture and distribution. Scientific advances were also absorbed by the new type of supervising official as these became available. These changes, together with a general improvement in educational standards, caused a new and wider emphasis to be placed upon food inspection and hygiene. This emphasis, coupled with the fact that the majority of officials were willing to assimilate up-to-date knowledge and to discard the police policy formerly employed, led to an increase in the number of manufacturers and distributors who consulted local inspectors regarding the day-to-day problems involved. What is perhaps even more important, the advice given was usually well received.

Prior to 1939 the Minister of Health was responsible, by statute, for the main supervision of foodstuffs throughout the country. A similar body acted in a like capacity in Scotland and Northern Ireland. As food came to be classed as one of the major factors affecting the community during hostilities, the Ministry of Food was constituted, its main purpose being to initiate and control proper methods of distribution. Matters were allowed to continue in this way until the end of the War, when the Ministry of Food became a permanent body, taking over the supervision of foodstuffs in so far as production and distribution were concerned. Failing a return to normal peace-time conditions, a new outlook in relation to the problem prevailed. Not only had a mass of new scientific knowledge become available for immediate use ; it was realised that the inspection of foodstuffs was by no means satisfactory in that all the problems involved were not receiving adequate attention. This produced a demand for improved methods in the production and distribution of food, the assumption quite correctly being that manufacturing methods, plant cleanliness and food handling were of paramount importance, and that failure to obey certain obvious requirements was likely to result in ill health or actual disease. As a result, there is now a new and more satisfactory outlook in regard to our food supplies, their inspection and treatment.

It is now fully realised by all concerned that food hygiene is, in fact, an important subject. Manufacturers and distributors have in most instances evinced a practical interest, and seem to appreciate that matters must be drastically improved if conditions are to be entirely satisfactory. On the other hand, the supervising official may be too meticulous in his requirements, while codes of practice tend to vary too much from district to district. Obviously, as in so many other fields, standardisation is required. In this connection it is important that an early lead be given by the central authority.

Public Health Requirements

From the public health point of view, the primary requirement in regard to all food should be that it is safe and capable of being sold in a suitable condition for human consumption. With this object in view, legislation has been introduced from time to time. Such legislation was designed to protect the consuming public from the dangers arising from infection, adulteration or abstraction, misleading labelling, unsoundness and unwanted chemical additions. In spite of the efficacy of such legislation, which varied considerably, further legal enactments, incorporating a more up-to-date appreciation of present-day needs, are required for consumer protection. Public health and other controlling officials are still called upon to spend a great deal of their working life supervising the preparation and distribution of food, collecting samples of various types for bacteriological and chemical examination, and prosecuting law-breakers. These, of course, are important duties, but they should never be allowed to obscure the wider issue. It is certainly true to state that the outlook has broadened during the past few years. It is now more widely recognised that the relation of food to health plays an important part in present-day preventive medicine. Sound food, in sufficient quantity, predisposes to a healthy, virile population ; this in turn cannot fail to be of inestimable benefit to the community as a whole. The medical branch of the public health service has gradually come to be recognised as a useful means of disseminating dietary knowledge. In this way the scope of the Public Health Department's work in relation to food supplies has been considerably widened, it having been acknowledged that sound, positive health is impossible unless assisted by the provision of a safe and suitable food supply in adequate balance and quantity. While this is undoubtedly true, the efforts of the medical profession will be nullified, at least in part, unless food is hygienically controlled. It is in this direction that progress is most to be desired.

Control Methods

The methods available for controlling the hygienic production and distribution of foodstuffs cannot be properly applied unless suitable and satisfactory legal backing is available, for use if and when required. It is to be regretted that existing legislation is not at present sufficient for this very important purpose. Although certain hygienic standards have been laid down, the enforcement of which is a duty imposed upon local authorities and their officers, these standards are not sufficiently clear and concise. One has only to consider the present food legislation to realise that, apart from meat and milk, which receive fairly detailed consideration, the bulk of our food supplies are dealt with in an extremely superficial manner. Primarily, legislation should give the controlling official a definite lead as to what standards are required. At the present moment the onus of drafting codes of hygienic practice is largely left in the hands of unofficial or, at least, semi-official bodies ; this is a matter which should be directed by the central authority. It is also important to remember that the publication and proper advertisement of any new food legislation and standards would arouse the consuming public to the realisation that only the best should be acceptable. Before any real enforcement programme can succeed, public backing for the campaign is essential. This will only result when the significance of the required standards is generally appreciated. Definite food standards are vitally necessary if the food trade is to be freed from those individuals and firms who are a stumbling block to progress, and if the industry is to have an opportunity to prosper as the result of improved hygienic handling and quality.

The majority of commercial concerns would readily conform to improved legislative requirements if these were put into force. The real difficulty lies in the fact that many might fail to do so unwittingly, because of carelessness or lack of thought. It is in this direction that education can best play its part. It is interesting to observe how often the advertisements of prominent food-producing firms make a point of stressing the hygienic methods under which their commodities are produced. This facet of their trade has proved to be of great value to such firms. The policeman-like attitude of controlling officials to the many problems involved has already been mentioned. Whilst in certain cases legislative powers may have to be used, much better results are more likely to accrue if more emphasis is placed upon *preventive hygienic measures*. The provision of the necessary technical advice or assistance, which may be given either personally by the official concerned or though the agency of advisory committees or similar groups, is readily accepted by the right type of manufacturer. There is also considerable scope for the proper organisation of a better system of inspection at the source of production. This has already been proved in other countries.

It must always be borne in mind that preventive measures represent the best and surest means of spreading the gospel of food hygiene. Much more good can be achieved by the prevention of faults in treatment than will ever result from prosecutions after the offence has occurred. Indeed, *persecution* might be a more apposite term, particularly where ignorance is responsible for the difficulty. It is much more satisfactory to ensure that hygienic methods are regularly practised at the point of production than it is to try to enforce a police programme, which must unavoidably mean the supervision of large numbers of premises from which the food is ultimately distributed in small quantities. There can be little doubt that educative measures do achieve results. Generally speaking, the better type of manufacturer tries to do what is right, since in the long run he finds that proper methods show maximum profits. This in turn exerts its effect upon the smaller trader. It must also be emphasised that law enforcement can achieve little success without public backing.

Control Officials

It will be obvious that any programme which aims at improving the hygienic production and distribution of food is likely to fail unless the right type of official is available to carry out the work. Specialised knowledge of the food industry is of prime importance. The sanitary inspector, who is mainly responsible for this work at the present time, is usually so overburdened with the miscellaneous duties thrust upon him by his local council and by the interested Ministries that he is unable to give the time required to the important duties related to food hygiene. A new method of training is urgently required, with a revised syllabus which should be based on the modern conception of food hygiene. Special officers should be appointed to carry out this work, while limitations in regard to local authority boundaries should be ignored. If this principle were followed, it is highly probable that the responsible officers would be more readily listened to by food manufacturers and distributors, since their specialised training and qualifications would be better appreciated. Not only should controlling officials be able to inspect, supervise and, where necessary, condemn the manufacture of food of all types ; they should have sufficient time to act as an educative force in relation both to the trade and to the consumer. They should be able to ensure that the consumer knows what to eat, and how contamination in the home can be prevented. Bacteriological knowledge, not necessarily advanced, is essential, together with a thorough understanding of the different methods of food processing. The basic training of the present food inspector aims almost entirely at law enforcement by means of a stereotyped policy ; the scope of such training should be widened on a specialist, more elastic, basis.

Additional training should be given in the technical and economic problems with which the food industry is faced, so that the responsible official can deal on equal terms with both manufacturers and distributors alike. Consumers should not be overlooked, as their point of view is important. As a means of support, an adequate laboratory service should be available. Many food hygiene problems can only be solved in the laboratory. This means that the official must, of necessity, keep abreast with current scientific developments affecting food hygiene and technology. To assist the present officials, more suitable courses, either for original training or of the refresher type, are an urgent requirement. Most of the courses at present being organised are suitable only for the factory hand or canteen employee, and, although these individuals form an important part of any educational programme, more advanced instruction is essential. The success of any campaign designed to improve food hygiene cannot be assured until the official outlook changes and until sufficient suitably-trained officials are able to devote their entire time and energies to the task in hand.

Benefits of Official Action

Legislative action, particularly in relation to the adulteration of food, has resulted in a marked reduction in offences of this type. On the other hand, disease prevention has not attained the degree of success which might have been achieved, due, in many instances, to the lack of time available for the necessary action to be taken and to inadequacy of the statutory backing. Admittedly the enforcement, so far as is possible at present, of hygienic control has assisted to some extent in reducing the number of epidemics attributable to milk. None the less, food-poisoning outbreaks still occur much too frequently in this country. Until more widespread hygienic control can be guaranteed, either by the education of those concerned or by legislative standards being fixed, this unhappy state of affairs is almost certain to continue. Lack of hygienic knowledge on the part of food producers, allied to inadequate measures of official control, also result in an enormous annual wastage of food. Here again official action is making headway, although progress would be more rapid if additional time were available for the propagation of educational measures. It cannot be too often emphasised that any wastage of food in these times of world shortage verges on a criminal act. Before the War, progress was being made in the wrapping and packaging of foodstuffs. Unfortunately, this improvement was allowed to lapse owing to war conditions. A wide field is available for exploration in this particular process, the food hygienist having abundant scope to effect much-needed improvements. Shortage of food has achieved one good result in that the shortage has made the public more conscious of the needs of the moment. A further result of this food-consciousness is the fact that associations of food producers and distributors are increasing their efforts to educate not only their own employees but also their customers. A steady growth in the public demand for a pure food supply is already showing itself. An extra effort within the next few years may well give the movement sufficient momentum to sweep away the majority of unhygienic practices. Hygienic handling, suitable packaging or wrapping, cleanliness of producing and distributing premises and accuracy in the description of the various mixed foods can only be fully realised with the help of all concerned. Official action can do much to achieve this desirable result ; but without the willing co-operation of the consumer such efforts will be largely wasted.

The proper hygienic control of food, backed by the pressure of public demand, is likely to exert a considerable effect upon the public health. Although minor attempts have been made during the present century to improve matters, no time is likely to be more favourable than the present in which to achieve real lasting results. That a substantial measure of improvement is necessary no one who has any knowledge of the present position can doubt. It will be equally obvious that the results already achieved should not blind those collectively responsible to the real position. By means of legislation and educational efforts, other countries have raised the hygienic position of their food supplies to a much higher level than has yet been attempted in this country. As has happened in so many other fields, the producer has lagged behind. From an æsthetic point of view, it is highly desirable that alterations and improvements in present methods be made ; from the aspect of public health, these changes are essential.

CHAPTER II

MANUFACTURING ASPECTS

Before any attempt at dealing with the many problems involved in the hygienic control of food supplies can be made, a clear picture of the manufacturing aspects must be provided. Primary difficulties in hygienic production are most likely to arise at the point where food is manufactured. For this reason, an outline of the various processes employed is a pre-requisite to proper understanding of the problem.

The food industry has not attained its present magnitude during the past few years, but has developed over a lengthy period from the original small manufacturing units to a macrocosm whose ramifications are widespread and equally complex. A number of professions are very closely linked with the extensive operations of the food industry. Thus scientists and engineers, applying their theories on a commercial scale, have helped to form one of the most important industries in the world. The basic facts regarding our food supply have been the result of extensive laboratory experiments, although it must be remembered that the financial assistance necessary to put these principles into practical use on a commercial scale, and to encourage the sale of the particular foodstuff when produced, has been provided from commercial circles. Science and commerce, closely linked, have thus been responsible for the growth of the present food industry.

Production Operations

The problem of hygienic food control is complicated by the number and variety of operations which may be involved in the production of even one type of manufactured food. When the innumerable types of manufactured food produced daily are considered the complexity of the problem will be more readily appreciated. The production of the basic foods, of which meat and milk may be cited as examples, are not so involved as the manufacture of many other types of food. It must always be remembered, however, that even the simplest operation can in itself produce a variety of hygienic problems. These problems do not usually present any insuperable difficulty, nor can they compare with more complicated methods of production which require a number of separate operations before the completed article is ready for sale. Taking food production methods as a whole, and giving due consideration to the many separate operations which may be required, it will be realised that proper classification of production methods is extremely difficult.

The solution of any particular problem may not be the end of the difficulties which are likely to arise in the manufacture of even one specified type of food. Just as speedily as an outstanding problem is solved so another arises. The discovery of the presence of various types of micro-organisms may necessitate complete alteration of all or part of the usual processing methods ; shortage of any particular ingredient may require the substitution of another comparable article and may necessitate radical alteration of the manufacturing process. Again, legislative standards change, bringing the need for altered methods. As an instance, recent requirements concerning the manufacture of ice-cream may be quoted. The final result of improved legislation is that manufacturing operations may have to be drastically altered to conform with the new conditions demanded. Perhaps the most acute problem arises from the fact that no two articles of food can be manufactured in a similar manner. Peculiar difficulties are also likely to arise in connection with new food products until some standard method of production has been elaborated. Until this takes place there is every likelihood that the final product will be sub-standard unless great initial care has been exercised.

In view of the special conditions which inevitably have to be met, it is important that the food hygienist should be fully aware of the problems likely to arise. It has been the unsatisfactory practice in a number of instances entirely to ignore or overlook the difficulties under which the manufacturer may labour and to enforce rigidly such legal standards as may be laid down. In adopting this attitude those responsible fail to make the most of the opportunities afforded to collaborate to the fullest possible extent with the producer. If difficulties should arise, and if these can be solved by mutual co-operation, the controlling official is afforded the unique opportunity of gaining useful knowledge, which may ultimately be employed to obviate similar difficulties in other food-producing premises. In this way the general interest will be served in the best practicable manner, whilst the official will obtain and retain the goodwill of the producer. This may be of great assistance to him in the future.

Manufacturing Trends

Since hostilities terminated, industry in this country has been undergoing change and reorganisation. In common with all other types of production and distribution, the food industry has tried, wherever possible, to advance with the times. As a result, considerable improvements have taken place in many directions during the last few years. These changes have to some extent been governed by the prevailing shortage of supplies. At the present time the food industry enjoys the great advantage of being able to participate in a sellers' market. It will be obvious, however, that this very satisfactory state of affairs is not likely to continue indefinitely. It is therefore highly desirable that improvements in technique and methods delayed by war conditions be put into operation at the earliest possible moment. If this is not done, only those producers and distributors who are fully equipped for efficient working, and who are carrying out what is a public duty in a satisfactory manner, are likely to survive the economic crisis, if and when it arrives. The food industry must take full advantage of the new and improved equipment and techniques which are becoming more readily available ; in addition, methods of distribution must undergo radical alteration. Finally, legislative standards and supervisory methods are likely to become more stringent in the future, due to pressure of public opinion. Only those progressive firms who have foreseen and understood present-day and future trends are then likely to find themselves in a really secure position.

The purchaser is rightly demanding that all processed products retain their original flavour and quality even after storage, and that food should not be the subject of any form of deterioration during its manufacture. From the hygienic standpoint, it is also essential that food be protected at all times from the dangers of infection and contamination and from the likelihood of improper human handling. Improved methods of preservation are now being exploited, a notable instance of this trend being the steady increase in the sale of frozen foods of all types. This enables the consumer to purchase seasonal foods in perfect condition at any time of the year. From the salesmanship angle it is now realised that improved appearance, packaging and wrapping are of the greatest importance. These not only assist the customer in his choice ; they provide greater convenience in distribution and improve methods of handling. Much research work has been and is still being carried out in relation to the nutritive values of various types of foods, and in the best methods of utilisation. In this connection, it may be noted that almost every firm of repute provides both menus and recipes in order that the most efficient and palatable use may be made of their products.

Innumerable new food products have appeared on the market since the termination of hostilities ; still more are likely to be placed on sale during the next few years. Throughout the food industry the present trend appears to favour more widespread and effective control of the hygienic quality of the article finally delivered to the consumer. From the economic point of view, numerous suggestions are being made for the greater utilisation of the many by-products of the food industry. Extensive economies both in manufacture and distribution are also being sought. Scientists are receiving increasing demands for the extension and utilisation of their knowledge as a means of ensuring the best possible product at all times. From the personnel aspect, the industry is training its staffs in the need for and in the practise of hygienic methods, while special attention is being paid to welfare activities. Finally, the trend of co-operation between industry and official controlling bodies has probably never been more favourable than it is to-day.

The food industry was slow in appreciating that science could be of material assistance to its development and progress. Now that this fact has been more fully realised there is noticeable eagerness to profit from scientific advances. Large food-producing concerns must, of necessity, possess their own research laboratories if they are to survive the keen competition likely to be met both now and in the future. Probably the greatest volume of research work being carried out at the present moment deals with the nutritional aspect of our food supplies, with particular emphasis on vitamin content, the value of enzymes, the basic constituents of food and their utilisation, together with the bodily requirements of varying age groups and classes of workers. The relation of nutrition to infection is also not being overlooked and has been the subject of considerable experiment. From the technical aspect, methods of heat-treatment, sterilisation techniques, food-preservation methods and food conditioning are the subject of much investigational work ; whilst public health technicians are dealing with the bacterial content of foodstuffs, methods of food infection and their prevention and food wastage through decomposition and staleness. If the industry is to survive to its own advantage, research work must go on, must indeed be considerably extended. Only in this way can any food-producing firm keep abreast of modern requirements.

Factory Hygiene

In conjunction with a more progressive outlook relative to the hygienic manufacture and distribution of foodstuffs, there has been a widespread recognition of the need for improvement in the methods of industrial hygiene as these are now practised. Many large firms have been pioneers in this field and have paid particular attention to the health of their workpeople. As a first step towards achieving progress in this direction, employees engaged in handling food were induced to care especially for their hands, whilst clean working overalls were quite often provided. In many instances employee supervision has now been extended to cover full medical examination of the personnel and the use of head coverings during working hours ; whilst washing accommodation with hot water, soap and towels—with admonitions as to the use of same—together with improved cloakroom and sanitary accommodation, have also been provided. Although the National Health Service guarantees free medical attention, it is now quite common to find a well-organised health service being maintained by the producing company for the benefit of its employees, full-time doctors and nurses being provided for the treatment of the workers, for dealing with injuries and for supervising the conditions under which the employees work. The same staff is also available for instructional purposes in connection with personal hygiene, acting generally as health consultants. It must be emphasised, however, that not all food-producing or distributing premises are operated on lines similar to those described, nor are the services outlined above universally available. Generally speaking, the larger firms are alive to the necessity for improved hygienic measures both as regards premises and personnel, realising that hygienic factories and sanitary methods of production are most likely to ensure a safe and suitable article which will have a ready sale. This type of firm also appreciates the fact that a healthy worker is more apt to be happy and therefore capable of maximum production. Difficulty is not likely to be experienced by the food hygienist in dealing with firms of this character. The smaller firms, many of whom are carrying on what might be termed backyard industries, are the most likely sources of faulty methods and general lack of care. It is appreciated that the necessary capital may not readily be available to enable such firms to provide better working conditions. None the less, it should always be emphasised that cleanliness costs little and that many small food manufacturers and distributors could attain a much higher standard of hygiene than they do at present. It is amongst such small producers that educative work is most required, backed by suitable legislative action in cases where education and advice fail to achieve their object. As has already been stressed, legislation, with its accompanying penalties, should only be invoked as a last resort.

Factory Control of Operations

Whilst legislation can achieve much towards bringing about improvement in regard to hygienic methods practised, advances in the quality of the articles produced or distributed cannot be attained solely by such means. From the business point of view purity is not sufficient in itself, since it is quite possible for a food to be pure and at the same time unpalatable. Over-processing, such as may occur in the case of milk, may ensure complete safety from the public health point of view and may not affect the purity of the liquid ; yet it may still result in a final article which has lost many of its valuable nutritive properties. The texture of ice-cream provides another instance of the truth that an unpalatable or coarse product may be perfectly safe but may still possess a reduced sales appeal. In short, safety in itself is not likely to increase the sale of any given article, at least until the customer is better educated as to what safety really means.

Many firms have fully recognised that official requirements, dealing as they mostly do with standards of quality, plant hygiene and the health of employees, are not sufficient in themselves to enable a really saleable product to be achieved. For this reason, such firms make calculated efforts to provide an article of standard quality. This important principle underlies many of the practices of factory operation now in existence. Apart from its safety, a quality article which is at the same time palatable possesses a certain public health value. Obviously, pure food maintains good health, but no consumer is likely to attempt to maintain his health by the increased ingestion of an unpalatable article, however safe for consumption it may be. For this reason quality control has assumed increasing importance during the last few years. Even the smaller firms are now becoming alive to this aspect of the problem and to their responsibilities in the matter. In many cases advertising literature lays particular stress upon the quality of the article marketed, on the assumption that the public will realise that hygienic production and quality go hand in hand. In spite of this progressive step, it cannot be too often emphasised that considerable improvements still remain to be carried out. The unsatisfactory producer must be made to realise that he can no longer foist a second-grade article upon a gullible public, which, being short of food or, at least, being short of variety, is willing and in many cases only too eager to try anything new which appears on the market. If such food producers cannot be induced by some form of educative measure to realise their errors and the dangers which may arise as a result of same, they must be quickly checked by means of legislation. If the present legislation is unsatisfactory for this purpose, as is all too often the case, it becomes the responsibility of the Government to ensure that suitable amendments are placed on the Statute Book.

CHAPTER III

CONTROL OF FOOD SUPPLIES

THE relative danger to health of various foods varies considerably. If not produced, handled or distributed in a satisfactory manner, most foodstuffs may become a danger to the health of the consumer.

Composition of Food

The significance to public health of the composition of food has not always received the consideration which it deserves. The nutritive value, which is based upon composition, is equally important, as is the susceptibility of the foodstuff to attack by pathogenic organisms. Food is composed of a number of constituents of varying quality from a nutritional point of view. *Water* is usually present in considerable quantity. *Proteins*, present in meat, milk and vegetables, are especially important. *Fats*, necessary to the general well-being of the consumer, are present in both meat and milk products ; whilst *carbohydrates*, which supply energy, are usually found in the form of dextrose or lactose when of the soluble type, or as one of the more insoluble varieties such as starch and fibrin. Most basic foods contain a certain percentage of *mineral matter*, dairy products, fruit, vegetables and whole cereal grains being noteworthy in this respect. *Acids* are found in varying quantities in fruits and vegetables, whilst *vitamins* present in various foodstuffs also possess nutritional significance. These basic constituents vary greatly from food to food, this being the feature which gives each food its characteristic nutritional value and governs the degree of spoilage which may occur. As an instance, flour does not depreciate readily in value, meat and vegetables deteriorate more quickly, whilst milk sours very rapidly and, being an excellent medium for bacterial growth of both the pathogenic and non-pathogenic types, may soon become dangerous to health. Some types of bacteria, e.g. those which cause spoilage, will grow readily in acid foods, whereas those organisms which are likely to affect the health of the consumer do not normally develop in foods of this type unless the acidity has been entirely neutralised. Again, the protein or carbohydrate content of food or the quantity of water which it contains may each or all prescribe the type of spoilage or deterioration likely to occur. Any investigation into a disease outbreak thought to be due to food can be materially assisted by a knowledge of the compositional value of the suspect food.

Autolysis of Foodstuffs

Many foods begin to undergo changes in composition after having been produced. Such autolysis is due to the action of the enzymes which the food contains. This autolytic action may be influenced by natural conditions such as the state of the surrounding atmosphere, sunlight, warmth or moisture ; whilst the action of certain metals, particularly copper, will accelerate the change. Autolysis results in the affected food rapidly losing its natural quality, in consequence of which its original nutritive value materially decreases. The action of the contained enzymes may cause loss of colour or flavour, the article no longer possessing its original freshness. At a later stage the vitamins originally present may be destroyed and the fats oxidised or split, resulting in the development of rancidity. When the proteins are attacked, decomposition follows, with the liberation of ammonia, sulphuretted hydrogen or other objectionable chemicals. Such changes rarely cause illness, since the affected food becomes so objectionable and is so obviously not fit for consumption that it is destroyed. Danger may arise from foods which are consumed when undergoing partial but unrecognised change. Decomposition *in itself* is not always responsible for gastric disorders, as was once the general opinion. Decomposition mainly causes a decrease in nutritive value, renders the food objectionable to the nose and palate, causes spoilage and waste and, what is most important, enables undesirable bacteria to obtain entrance to the food.

Bacterial Infection

Food is particularly susceptible to bacterial infection, the extent of this susceptibility varying according to the type of food concerned. All micro-organisms require nutriment for their development, multiplying rapidly under favourable conditions of temperature when suitable nourishment is available to assist their growth. All food contains bacteria, either internally or on the external surfaces, but until favourable conditions, either of temperature or moisture, are present such bacteria may lie dormant. Not all the bacteria present in food are pathogenic or even undesirable, as is instanced by the process of fermentation. Here the action of the right type of organisms is necessary to complete what is often a valuable process. Mouldiness in food is objectionable, as is souring in the case of milk. These conditions are due to undesirable bacteria, many of which obtain entrance through lack of care in methods of production and distribution. The action of all types of bacteria assists in the breakdown of the various constituents of food, assisting in the formation of end-products or toxins which may be extremely dangerous under certain conditions. *Pathogenic organisms* are especially dangerous in that their growth in any particular food may be sufficient to cause dangerous infection. Food poisoning is frequently caused by the toxic products elaborated by pathogenic bacteria in the food itself. These toxins increase in virulence when the affected food is consumed in a stale condition.

If food could always be protected from bacterial infection and multiplication, the need for more stringent measures of hygienic control would not be so clamant. As matters stand, however, this is not at present feasible. For this reason it is of particular importance that food be produced and handled in a proper manner so that contamination, whether bacterial or otherwise, can be reduced to an absolute minimum.

Nutritional Aspect

For many years it was held that, if food contained its proper proportion of fats, proteins, carbohydrates and other essential constituents, this was quite sufficient in itself. This energy value was normally expressed in calories. It was usual to calculate the protein content by determining the organic nitrogen content, from which figure the desired percentage was calculated by multiplying with the constant figure of 6·25. Further investigations have shown that all foods contain a certain proportion of fibre, much of which is largely indigestible. The value of this fibre (roughage) as a bowel stimulant has only been recognised and properly evaluated within comparatively recent years. It was not until the biochemists, ably led by

Hopkins, began their extensive experiments that animals fed with foods of similar chemical composition were shown to produce different growth rates. These experiments clearly demonstrated the fact that food possessed certain other constituents whose effect upon the health of the consumer was still unknown. Later, the importance of the vitamin content of food was brought to light, while proteins were classified into two main groups. One of these classes possessed, as part of their composition, certain quantities of amino acids which were proved to be essential to adequate body building. The second class of proteins was found to be lacking in this desirable constituent. It would appear reasonable to assume that biochemists, continuing their work, will make new discoveries which are likely to alter still further current ideas as to nutritional values.

Dietary Requirements

Nutritional research is continually bringing to light new food constituents which are apparently necessary for the promotion of satisfactory health. The basic elements, such as oxygen, carbon and nitrogen, together with water are, of course, important, but more food constituents have assumed much greater significance, particularly within recent years. *Amino acids*, present in varying quantities in proteins, have received considerable attention, although it is realised that all types of protein do not contain sufficient of these acids to support vigorous life. Further, the ingestion of one type of amino acid is not sufficient in itself, two or more being required to satisfy completely nutritional requirements, irrespective of the nutriment obtained from other sources. It is known that some of these acids are synthesised in the body, although their precise nutritional value has not yet been ascertained in all cases.

Vitamins are of particular importance to healthy life. Whilst many are known and their effect as part of the daily diet determined, the total continues to increase as research workers carry on their experiments. Some of the vitamins originally thought to be simple elements have lately been demonstrated as compounds, an instance being vitamin B, which has been shown to be capable of division into several fractions. Many of the vitamins are chemical compounds. It has been found possible to synthesise some vitamins in the laboratory. In this way vitamin A has been produced synthetically from carotene, although the richest natural sources are eggs, dairy products and green vegetables. Lack of vitamin A results in affection of the eyes, such as night blindness ; the mucous membranes and the urinary organs may also be affected. The vitamin B complex is interesting in that it has been split up into fractions which include vitamin B_2 or G, as it is sometimes known, which has been given the name of riboflavin, together with panthenic and nicotinic acids. Vitamin B_2 or G is present in fresh fruits and vegetables, in meat of certain types and in milk and eggs. Vitamin B is also widely distributed in foods of animal and vegetable origin and is found extensively in the outer husks of grain and other cereals. Any serious deficiency of this vitamin will result in beriberi, a disease responsible for the degeneration of the nervous system accompanied by cardiac disturbance, atrophy of the muscles and œdema, although impaired health may result without any of the classic signs of the specific disease being present. If the body is deprived of the vitamin G fraction, pellagra may ensue, due to deficiency of the nicotinic acid fraction. If this condition is severe, skin rashes, oral sores, anæmia and digestive or nervous disorders will result.

Riboflavin deficiency results in oral lesions. It should perhaps be noted that both beriberi and pellagra are extremely rare—indeed almost unknown—in this country, although mild forms of vitamin B deficiency are probably commoner than was formerly believed. Vitamin C is recognised as the main anti-scorbutic agent and is found in fresh milk, although not to any great extent. It is present in large quantities in fruit and vegetables, particularly citrus fruits, rose hips, blackcurrants and tomatoes. As the anti-scorbutic vitamin, any extended lack of this element will result in scurvy, joint soreness, gum and tooth disorders and poor calcification, with lesions of the bones. Vitamin D, the " sunshine " vitamin, is present in fish oils, fats, eggs and milk. Any continuous deficiency of this vitamin will result in rickets, calcium and phosphorus being insufficiently utilised, so that good bones and teeth are not formed. Vitamin D can also be produced in the skin through the action of ultra-violet light on ergosterol. Vitamin E has not been shown to be of any great importance in relation to human nutrition but is reported to affect fertility.

It has not been proved that lack of vitamins in the diet definitely lowers resistance of the body to infection. It can be assumed, however, that a diet lacking in these elements is inadequate for healthy life and that the body will thereby be more prone to infection. It is especially important that an adequate diet should be available during the early years of life ; to be entirely adequate that diet must contain its proper share of vitamins. Generally speaking, although a diet containing a low vitamin content does not react unfavourably upon the consumer as regards pathogenic infections, a diet of this type would tend to predispose to disease. It is also true to state that, unless the diet is already deficient in vitamins, little general improvement in health will result from an added intake of these elements. There is positive evidence that any lack of the full quota of vitamins A, B and C in the diet does cause appreciable loss of resistance to various types of deficiency diseases. There is, however, little evidence that the direct admixture of vitamins to food will result in an immediate decline in any type of disease. These elements act over a period of time, while it must be remembered that dietetic deficiencies cannot be immediately overcome. It has also been shown that vitamins assist in the maintenance of the bodily structure. Some vitamins may be readily destroyed by the faulty processing of foodstuffs. This should be constantly borne in mind by nutrition chemists and engineers when devising any form of food-processing plant.

Instances of severe avitaminosis are, of course, rare in this country. The problem more or less confines itself to mild manifestations of vitamin deficiencies, in which signs and symptoms are difficult to detect. The effects of such minor deficiencies are not easily determined. As already indicated, however, the cumulative result may upon occasion be significant.

Formerly the *mineral content* of food was not considered to have any great significance and was apt to be overlooked. Researches have since proved that lack of suitable mineral matter in the diet can produce serious results. Both animal and vegetable foods contain certain amounts of mineral matter, the quantity varying with the type of food concerned. Such variations are due, *inter alia*, to the environment in which the food has been produced. If the requisite standard of bodily health is to be adequately maintained, certain mineral salts must be present in the foods consumed. Lack of *calcium* and *phosphorus* will produce bone defects, faulty teeth, dental caries and may also, in association with deficiency diseases, result in rickets. *Copper* salts are of some importance in that they assist in the utilisation of the iron salts by the blood. If these latter are absent or substantially deficient, anæmia and defective body cell structure may result. Thyroid deficiencies may be due to lack of *iodine* in food, goitre being a notable instance of this mineral shortage. The remaining mineral requirements of the body are adequately available in any normal diet. Faulty food processing may result in the destruction or impairment of any or all of these elements.

Fats are heat providers, furnishing fuel for the body. Lack of fat predisposes to disease and gastric disturbances, over-eating being discouraged if the diet contains an adequate quantity of fat. The needs of the digestive system are then satisfied. due to the digestive processes being retarded by the fatty acids present.

As energy producers *carbohydrates* are important. If the daily diet is lacking in a sufficiency of these substances, the body loses its energy and has to draw upon the fat content of the body tissues. Loss of weight then results. If this process is continued for any length of time, starvation is likely. Similarly, if carbohydrates in the diet are not present in adequate quantities, the protein content of the food consumed will be called upon to make good the loss of energy. Lack of these substances causes the body to lose its heat, so that, if the fat in the diet is to be properly metabolised, carbohydrates must be present in sufficient quantity. In addition, carbohydrates must be sufficiently oxidised if the fat is to be properly utilised. Of the various types of carbohydrates, *lactose* is probably the most important. The best source of lactose is milk, although smaller quantities are present in eggs, while traces have also been found in certain vegetables.

Malnutrition

Malnutrition is a wide, somewhat elastic term embracing the bodily state which results from under-feeding or from the continual intake of a badly-balanced diet. It may be present to almost any degree, from the mildest manifestation, not easily detected, to a very obvious condition bordering on starvation. Our knowledge of malnutrition has been greatly extended during and since the War, particularly among peoples of enemy-occupied countries, displaced persons and prisoners or war. The symptoms of malnutrition disappear fairly rapidly when an adequate diet is once again provided and when existing deficiencies are corrected. It is important to remember that malnutrition may occur not only where there is an over-all shortage of all types of food, but also where reasonably adequate food supplies are deficient in certain essential requirements. Extended experiments have proved that under-nourishment results in lack of effort, in backwardness and in decreased resistance to infection, conditions which are normally absent when a properly balanced diet is consumed in adequate quantities. Lack of food may, indeed, reduce an individual's expectation of life by many years, particularly if the shortage has occurred during the early years of life. To prevent malnutrition the intake of food must exceed the bodily output by a small margin. As already noted, the balance must also be maintained.

Protective Foods

Nutritional experts have been aware for many years that certain foods are capable of exerting a protective influence on health. The level of nutrition naturally varies from country to country, from one type of climate to another, and also in accordance with the economic level of the population concerned. Where the diet consists mainly of carbohydrates or foods of high protein content the protective foods necessary to maintain adequate health would be milk, green vegetables and fruit. Where the diet is normally lacking in proteins, meat or fish would represent the protective foods required to establish a proper dietary level. It should also be noted that, where individuals are forced to exist for the most part upon ready-made or canned foods, as is the case in many of our industrial areas, fresh fruits and vegetables are essential if an adequate diet containing the proper proportion of protective foodstuffs is to be guaranteed.

Food Decomposition

At one time the decomposition of food was believed to be the cause of various types of gastric disorder. This belief has now been found to be almost entirely erroneous. It is quite a normal practice to eat both game or venison in a " high " condition, or when decomposition is well advanced, without any ill-effects. This also applies to certain varieties of cheese. Foods of this type often exhibit an offensive odour, while they are not attractive in appearance. In the majority of cases they would be rejected on these grounds. Ptomaines are generally present to a greater or lesser extent when decomposition is far advanced, but in this state the food is quite certain to be rejected. On the other hand, when bacterial infection with members of the Salmonella group or staphylococci is present, little change in the outward appearance of the affected food is likely to be observed. In short, there is little if any relationship between food decomposition and food poisoning. When bacteria attack proteins in food, ptomaines are produced. As these substances are highly resistant to heat, cooking or sterilisation will not destroy them. It is possible that both toxins and ptomaines are produced by bacteria at one and the same time, but any illness which occurs following the ingestion of such affected food is almost invariably due to the effect of the toxins.

A suggestion has, however, lately been made that cases of outbreaks of minor food poisoning in which a causative organism has not been identified may, in fact, be due to the end-products of food decomposition. This may be so, although it appears more probable that the true explanation lies in the fact that the infecting organism or its toxin have escaped isolation.

Over-eating may cause intestinal disturbances the effects of which may be mistaken for some form of food poisoning. This, however, is not likely to occur generally in this country at the present time. Again, certain individuals are allergic to some types of food and suffer from digestive or skin complaints when the responsible food has been consumed. It does not, however, follow that because an individual exhibits a marked dislike to a certain type of food he is necessarily allergic to it. In most instances the medical history will reveal whether or not an individual is allergic to specific foodstuffs. Proteins are particularly important in producing this effect, but other food constituents may be just as noxious. Allergy can be quite easily discovered by feeding portions of the suspected food to the person undergoing examination.

Food Control

The majority of infections to which foods are subject are due either to carelessness in production or handling, lack of hygienic methods, indifference to basic requirements or absence of sufficient knowledge in regard to the food concerned. For those reasons, adequate control is essential. Educational measures will almost invariably effect improvement, particularly where the operators concerned are willing to take advantage of the scientific knowledge available and to improve the conditions under which production and distribution are being carried on. It is to be regretted, however, that education is not in itself sufficient. There are still quite a number of individuals engaged in the manufacture and handling of food who do not appear willing to learn and who require legal compulsion. In such cases as these it will be obvious that strict supervision by the controlling official is essential. Where existing methods are generally satisfactory, such control may seem at first a waste of time. This, however, is not the case. It must always be remembered that adequate control will ensure that the public can have full confidence in the foods which they purchase, while careless or dishonest producers and distributors are prevented from gaining an unfair advantage over their competitors. Without proper methods of control and supervision the food industry might very speedily revert to the unsatisfactory state of affairs from which it has all too recently emerged.

Controlling Bodies

The primary control of our food supplies by means of legislation must be vested in the State. As at present determined, the main *State supervision* of methods of food treatment and handling is vested, by a recent Order, in the Ministry of Food, although the Ministry of Agriculture and Fisheries is responsible for the production of raw milk, while the Ministry of Health deals with food in relation to the public health. The Ministry of Food, formerly a war-time organisation but now a permanent State department, is the accepted choice for responsibility in this vital matter. Not only is the Ministry of Food concerned with ensuring that sufficient food is provided for consumption ; it is also responsible for equitable distribution of foodstuffs and must, of necessity, be intimately concerned with the quality of all foods reaching the producer and finally the consumer. For this reason it is probable that future legislation which deals with the control of foodstuffs will be initiated by the Ministry of Food, although the Ministries of Health and Agriculture and Fisheries are likely to be intimately concerned.

The legal basis for all food control operations is the Food and Drugs Act, 1938. As might be expected, however, many changes have become necessary since that date, resulting in a multiplicity of Acts, Orders and Regulations which deal with the legal aspect of food treatment and handling. That food hygiene is recognised by the Ministry of Food as being of very considerable importance is clearly indicated by the fact that the Ministry has now formed a food hygiene section, which will exert a supervisory function. Direct control, however, will continue to be exercised by various types of local authorities, usually through their public health departments. The Ministry of Agriculture and Fisheries deals with raw milk production in its entirety. Supervisory powers, which are exerted directly, include the supervision of raw designated milk production. Control is exercised through the County Agricultural Executive Committees, while the day-to-day control is in the hands of milk production officers who are members of the National Agricultural Advisory Service, which is a Ministerial organisation. Central Advisory and County Advisory Committees assist in consideration of amendments of the various Milk Regulations as required, and generally ensure that the existing legislation is satisfactory for the purpose for which it was designed.

The functions of the Ministry of Health in regard to food supplies are now mainly concerned with the prevention of infectious diseases and outbreaks of food poisoning, which are, of course, the direct concern of the various local authorities and their medical officers of health, assisted by sanitary inspectors and health visitors. The legislation now available aims at protecting the consumer by promoting the purity and proper labelling of food, the prevention of adulteration and the abstraction of vital nutritive elements, improper practices in manufacture, and the hygienic control of production and distribution. As will be seen, the legislation is designed to prevent infection and illness. Its aim is the prevention of the sale of unsound, diseased or unhealthy food and the enforcement of certain essential quality standards. It is to be regretted that much of the legislation at present in existence is drafted in extremely vague terms. An entirely new *Food Code*, which would deal in an adequate manner with all vital principles and modern practices concerned, is urgently required. Wide scope exists for investigation by food inspectors into current methods of manufacture. Many large food manufacturers and distributors would be only too willing to co-operate in this respect. Up to the present little attempt has been made to achieve this object ; equally scanty provision has been made for experimental investigation in any of the legislation now available. Considerable assistance could be rendered to food firms by the various Ministries, who have available both specialist officers and extensive laboratory services completely staffed with highly-trained personnel. Watch is continuously kept upon existing food standards, particularly in regard to the new foods which frequently make their appearance. Complete reports from local bodies of work carried out by them are annually required. The Ministry of Health makes detailed investigations into food-poisoning outbreaks, their published reports providing valuable information for all interested in the prevention of food-borne infections.

In spite of the improvements brought about by means of legislation, too little direct control is exercised in this country by the State departments concerned. With the solitary exception of raw milk production in all its forms, the central authority is prone to leave the direct control of food production and distribution to the various local authorities and to trade associations. This country lags behind many other nations which have instituted adequate central control methods in addition to those provided by local bodies. It may be that local influence is too strong and that any suggestion of central control is thought to savour of interference. None the less, the nation's food is much too vital a matter to be allowed to remain at the mercy of local or sectional interests. Improvement in this direction is urgently required.

The *local control* of food supplies varies greatly. Much of the administration of the Food and Drugs Act, 1938, and of many of the Orders and Regulations relating thereto, is placed in the hands of county and county borough councils. This is particularly the case in relation to standards of quality. The smaller councils, usually municipal boroughs or urban and rural district councils, are mainly responsible for the condition of food premises, meat and food inspection, slaughter-houses and the supervision of retail premises, together with the general enforcement of sanitary conditions in all food factories, so far as legislation permits. These duties are additional to many others, probably thought to be of equal importance. It will thus be obvious that insufficient time and thought is available for dealing with this very important matter. The Government, by vesting powers in the Ministry of Agriculture and Fisheries, has recognised that local officials are unable to give adequate attention to the problems involved in the production of raw milk on the farm. It should be equally obvious that food control in all its hygienic aspects is the affair of the specialist, who should be outside the orbit of local influence. The time will probably come when the supervision of food production and distribution, and many problems which this work involves, will be placed in the hands of the State and State-appointed officials who will have the time available and possess the specialist knowledge to overcome the many problems which arise. Present tendencies are directed towards the State control of many industries, with or without nationalisation. In no section of industry is control more necessary than in the food trades. The whole problem should be viewed from a wider angle, particularly in relation to educational measures, without which legislation is largely valueless. Only when the responsible officers have sufficient time to devote to their work can worth-while advances be made. Minor attempts at improvement are continually being made, but this type of inadequate approach can scarcely be expected to achieve the results desired.

No general discussion regarding the supervision of food supplies would be complete without some mention of the *control exercised by the trade* itself. Obviously this method of approach to the problem is not universally employed, since every tradesman is not a member of a trade or professional association. The food trade generally is becoming more keenly aware of its responsibilities in the matter of control, the larger firms having been the instigators of more progressive methods in matters appertaining to the manufacture and distribution of foodstuffs. Whilst the profit motive should never be overlooked, there can be little doubt that the majority of these firms realise that pride of achievement is of prime significance, their desire being to produce a safe and wholesome article of food which is of benefit to all concerned. In order to achieve this end they provide laboratory facilities, while many firms spend large sums of money annually in a genuine effort to improve the final quality of their product. The result of such activities has been to force many of the smaller firms to adopt similar measures in order to compete favourably in the open market. Trade associations have played and, it is hoped, will continue to play a most important role. Many of these have brought pressure to bear upon the central authority in regard to necessary improvements in food production and distribution. They have also given considerable assistance in the educational work involved. In addition, many such associations provide specialised technical assistance for the small producer and distributor, fix standards which should be attained and generally try to ensure that the particular food supply with which they are directly concerned is hygenically handled. This good work would be considerably enhanced if more small traders could be persuaded to join a progressive trade association.

One must also consider the *private bodies* interested in the food trades, a number of which are making great efforts to obtain improvement in existing conditions. The *Royal Sanitary Institute* has provided courses of training in food hygiene which could be more widely attended, while their Congress programmes almost invariably feature discussions dealing with this very vital matter. Similar courses have been formulated in milk processing and ice-cream production and distribution. The *Institute of Public Health and Hygiene* issues certificates of purity in regard to foodstuffs produced and handled under conditions which receive their approval. This latter point is one which might profitably be extended. Whether the certificate should be issued by a private body or whether the central authority should provide the guarantee is a matter for future decision. In addition to the bodies already mentioned, there is the *Central Council for Health Education*, vitally interested in the purity of our food supplies. Innumerable citizens' associations, women's clubs and the like also play a useful part. The interest of these organisations causes them to bring pressure to bear, either directly or through their elected representatives, upon the State or local authority with a view to achieving necessary improvements. If maintained, pressure of this kind is likely to produce practical results, always provided that it is directed in a reasonable manner.

Official Procedure

The basis of all official procedure designed to ensure the hygienic production and distribution of food is *inspection*. This must be carried out with suitable regularity and efficiency. Intermittent inspection is of very little value. If the work is to be really effective it must be carried out with proper emphasis on the methods involved. Casual visits are of little value and should not be tolerated. The controlling authorities should appreciate this fact and provide an adequate number of controlling officials in order that the work may be carried out in an efficient manner. The officers selected for this work should have received an adequate training in food technology. They should also be capable of detecting such faults as may exist, should know how these faults may be remedied, and how their re-occurrence may be prevented. When it is considered that their main duty under existing conditions is to ensure that legal requirements are fully complied with, it is quite obvious that prevention is of particular importance, particularly as work of this nature possesses considerable educational value. If the inspector concerned possesses full knowledge of the process or processes involved, he is likely to achieve better results, particularly as ignorance of the methods employed will most certainly be quickly detected.

Although the examination of samples of any food under review will usually give a fair indication of its quality, it is important to remember that this procedure affords little or no information regarding the conditions under which it has been produced. Accordingly, the inspection of premises and methods can never be discarded as useless. Cleanliness of the processing and preparation rooms, ventilation and lighting, air-conditioning measures, if such are employed, sanitary accommodation, drainage and water supplies, fly and other infestations—these are some of the many points which require constant attention and whose adequacy or shortcomings are not likely to be discovered in the laboratory.

Infestation with vermin is a matter which must be the subject of the strictest inquiry, since food factories and distributing premises usually attract insects and rodents in large numbers. The measures adopted for the control of infestation and for the destruction of invading vermin should be closely investigated, while the means available for preventing the entry of rodents into premises should receive special attention. Insect pests, whether infesting the food supplies or their basic ingredients, must also be considered, the control operations in use being carefully checked. When considering vermin or insect pests for which poisoned baits are employed, it is important to note what protection is provided for the food or its constituents. Such investigations should never be omitted.

Apart from premises in which food is prepared, still more attention should be paid to the conditions and methods which exist in restaurants and other establishments where food and drink is sold, mainly for consumption on the premises. Quite often such kitchens are found to be in an indescribable condition, demanding drastic improvement in methods and in existing sanitary conditions. Methods of food handling in premises of this type are often equally unsatisfactory. When any attempt is made to improve conditions, greater use might be made of the *score-card system of inspection*. The adoption of this method quite often stimulates the proprietors of the premises involved and results in improved methods, with an accompanying rise in the standard of hygiene.

One of the duties of the controlling official is to obtain *samples* of the various foods exhibited for sale. The way in which these samples are obtained is extremely important, and several points require to be noted. To be fair to all parties, each sample should be representative of the bulk under review. Legislation requires that all samples obtained for food and drugs purposes, as a result of which legal proceedings may be necessary, should be divided into three portions, of which the vendor receives one part. The second part is retained by the sampling officer, the third being forwarded to the public analyst for examination. Bacteriological samples are not required to undergo this tri-partite treatment. Provided sufficient liquid or material is obtained in a suitable manner for the examination required, those responsible for the bacteriological examination will be satisfied. Particular care is necessary in handling samples after they have been obtained. In this connection samples to be submitted for bacteriological examination must receive special attention in order to prevent any marked rise in their bacterial content before examination takes place. Milk and ice-cream are two examples of materials which are particularly difficult to handle. All samples obtained for statutory purposes should be properly sealed with wax in order to ensure that they have not been tampered with either before, during or after transit to the laboratory.

The usual *basis for sampling* is at the rate of three samples per annum of all articles per 1,000 population. The schedule should be carried out in a systematic manner so that all vendors receive attention. The articles to be sampled should cover as wide a range as possible, bearing in mind the prevailing brand of adulteration. Two samples are employed, formal and informal. In the case of *formal sampling* an assistant should always be present to provide corroborative evidence. *Informal samples* sometimes act as a deterrent and may allow the detection of defects in storage, sale or distribution. An authority in writing permitting the officer to take samples should always be carried for production as and when required.

The *purchase of samples* is important. The article required should be clearly stated. The quantities set out in Table 1 on p. 26, which represent normal purchases, should always be demanded. It is usual for the analyst to state the quantity desired, but in every case the amount purchased must be sufficient for analysis. Before making the purchase the sampling officer should have decided what is to be obtained. The purchase of each sample should be distinct and separate, ordering and paying being carried out by one person. The actual amount of money required should be tendered if at all possible. Food normally retailed in unopened containers should be purchased in such containers, and any goods sampled should always be of the same manufacture. Detailed and accurate notes should invariably be kept of any statement made and of all other matters relating to the transaction.

TABLE I

Quantities required for Formal Samples

Article	Quantity required	Article	Quantity required
Bacon	½ lb.	Jellies	½ lb.
Baking powder	½ lb.	Milk or cream	1 pint
Beer	1 pint	Mineral waters	2 pints
Black puddings, polonies	1 lb.	Mustard	4 oz.
Bread	1 loaf	Oatmeal	½ lb.
Bread and butter	12 slices	Oils (various)	4 oz.
Butter and other fats	1 lb.	Pepper	2 oz.
Cake	½ lb.	Preserves	1 lb.
Canned or bottled fish, fruit or vegetables	1 b.	Pulses	1 lb.
		Rice, sago, tapioca	½ b.
Canned or bottled meats or pastes	½ lb.	Salt	1 lb.
		Sauces	2 pints
Cheese	1 lb.	Sausages	1 lb.
Coffee, cocoa or chocolate	½ lb.	Spirits	3 doubles
Condensed or dried milk	4 oz.	Spices	2 oz.
Cooked meats	½ lb.	Suet	½ lb.
Cordials	8 oz.	Sugar	1 lb.
Dried fruits	1 lb.	Sweets	1 lb.
Drugs	4 oz.	Tea	4 oz.
Eggs	1 doz.	Vinegar	10 oz.
Flour (various types)	½ lb.	Wines	1–2 pints
Fresh fruit	1 lb.	Yeast	4 oz.

The original wrappers and containers should be retained for use in case of a prosecution. On completing the purchase, the vendor should be informed immediately that the article purchased is to be analysed by the Public Analyst.

Although most articles are easily divided into three parts, difficulties arise in this connection. For chemical examination, *milk* in bottles should be thoroughly mixed. The cap of the bottle should then be removed, the liquid poured into a jug and returned to the bottle. This operation should be repeated three times. Loose milk in churns and cans should be plunged rapidly six times or poured from can to can three times. Milk should not be mixed with a dipper. In the case of *bread and butter*, the slices purchased should be placed butter to butter and each sandwich divided into three parts. *Butter, lard and other fats* should be wrapped in paper but should be inserted in wide-mouthed jars with as little pressure as possible, so that the moisture content is not pressed out. When dealing with *sausages*, each sausage should be divided into three parts. *Jam, condensed milk and similar articles* should be thoroughly mixed before division takes place. The container used for jam should be of the exact size required. Care should be taken to ensure that the sugar content of *condensed milk* is equally divided. This also applies to the fat layer on the upper surfaces of *potted meats* and *pastes*. In the case of *bottled preparations*, the contents should be mixed before division, if more than one bottle is obtained. *Mixed articles*, such as tinned peas, fruits, sardines in oil and any canned goods containing liquids, should have each large solid part divided into three portions. The liquids present should be divided as equally as possible. *Whole fruits* should be cut into three portions ; *spirits* should be properly mixed before division. In the case of *prescriptions*, the height of liquid in the bottle should be marked so that the analyst is able to measure the total quantity and check directions for dosage. Medicines containing sediment should be well shaken before division is made. When sampling articles in the form of *powders*, one dozen of the same variety, and all of the same make, should be obtained. These should be well mixed and divided. When *fish* is scarce, substitution sometimes takes place. Care should be taken in dividing the sample intended for expert examination so that it bears some distinguishing mark, such as the lateral line, for identification. Samples obtained from *automatic machines* are divided in the usual manner, one portion being forwarded by registered post to the owner of the machine from which the sample was obtained.

Special care is necessary when *samples* are *taken in course of delivery*. Samples of food, *but not drugs*, may be taken in course of delivery on request. It should be noted that these are not purchased but are taken. No consent is necessary in the case of milk, but the officer must be present at the time of delivery. A sample of milk is obtained either from the churn or from a mixture taken from all the churns in the consignment. The analyst should be informed of the approximate quantities in the various churns, while note should be made of the time and place of sampling, the method of transport, how the milk was mixed, and the condition and marking of the churns. The accompanying labels should be retained ; the gallonage stated on the labels should be checked. A sampling officer may take samples in the districts of other local authorities. If taken by the officer of one district at the request of an officer of another area, a certificate stating that the provisions of the Food and Drugs Act, 1938 have been complied with must be produced or the officer called as a witness. A copy of the certificate together with a copy of the analyst's certificate should be served with the summons. *Appeal-to-the-cow samples* are taken at the request of the producer and are marked "Appeal-to-the-cow." Several inspectors may have to be present in order to ensure that the entire milking process is under observation.

Division and sealing of the samples should be carried out in full view of the vendor, who should be allowed to verify the identity of the labels attached to the three portions. These labels should accurately describe the article and bear an identification number and date. Corks should be pushed into the neck of the bottle, the protruding portion cut off, the whole covered with sealing wax and the seal applied. Anything which cannot be effectively sealed in this manner should be enclosed in an envelope and sealed. The container and the envelope should both be labelled. When taken in the course of delivery, the vendor's portion should be sent by registered post together with an enclosure stating that the sample has been taken for analysis. The time and place should be indicated. The portions of all samples retained by the official should be stored in a cool dark place, preferably a locked refrigerator.

If the results of the examination are unsatisfactory, one of two lines may be followed. In the case of a minor offence a *warning* may be sufficient. Only one warning should be given. If the analyst's report indicates that gross adulteration has occurred, that pollution has taken place or that there is failure to comply with any legal standard, *prosecution* should follow. In some instances licences or registrations may be revocable or subject to cancellation. This penalty should never be invoked in the case of a first offence.

Certain types of foods are often subject to a condemnation procedure following surrender by the owner. Alternatively, they may be seized if the owner refuses to surrender them. Foods which are voluntarily surrendered require little attention as they are usually surrendered at the request of the owner, who is fully aware of their unsuitability for human consumption. When an article is seized from an owner who refuses to surrender it, as in the case of meat, a magistrate's order is required for its destruction. In the case of a prosecution, great care should be taken to prepare the evidence upon which the action is to be based. The testimony in court should be given in an unhesitant, unbiased and straightforward manner. Nothing is more likely to prejudice a case in favour of a defendant than evidence given in the halting manner of a person who is not completely conversant with the subject under consideration. When the general health of the community is at stake, the supply of a particular foodstuff may be suspended on medical grounds, usually on the instructions of the medical officer of health for the district concerned. In such circumstances great care must be taken to ensure that the food in question is really at fault, otherwise an action for damages may result. In any event it is usual to compensate the producer for loss of revenue.

When legal proceedings are taken in cases brought to court on behalf of the State, these are usually dealt with by the Treasury Solicitor or some member of the legal profession approved or appointed by him. In cases brought by county and other councils the town clerk, a member of his staff or the clerk of the council usually presents the evidence, although when difficulties appear likely to arise an outside solicitor or barrister may be briefed. Prosecutions are only undertaken by the local authority after very careful consideration with a view to protecting the consuming public. In spite of this, fines for proved offences are often most inadequate and offer little inducement to controlling officials to continue to bring such actions. Much more benefit would result if licences were issued for the production and sale of all foods, such licences being liable to withdrawal following a second or third offence. The law is of little use if it cannot be properly applied and unless it can be guaranteed to act as a suitable deterrent against future offences.

The usual procedure laid down in the case of premises in which structural conditions are unsatisfactory or where methods in use are under suspicion raises many difficulties. In normal times too many trades can start to operate without real let and hindrance. At present, however, most food-producing and distributing businesses require a licence from the Ministry of Food. This form of licensing is of little assistance to the public health official who is charged with controlling both premises and the operations. If a new food code is drafted, provision should therefore be made for any licence issued to be cancelled following serious infringement. If licences were granted in every case by the controlling authorities, it would be possible to exercise some control over the manner in which a business commenced operations, as is the case with milk, ice-cream and other dairy products at the present time. All applicants who wish to handle food in any way should be required to give certain information, which could be checked by a visit to the premises. If the statements made in the application were substantiated, a licence might be issued provided the methods were also satisfactory. If conditions or methods were unsatisfactory, suggestions as to alterations or improvements could be made before any licence was granted. In all cases of violation of the existing licence, written notice should always be given to the offender. This procedure is of great assistance should legal proceedings be necessary, since proof then exists that the defects or unsatisfactory conditions have been brought to the notice of the offender.

It should not be thought that the legal authority which the controlling official possesses is the only means by which he is able to deal adequately with food supplies. *Education* must never be overlooked. By reason of his intimate contact with both producer and distributor the food officer is able to carry on a great deal of educational work which, if properly exploited, will be of inestimable benefit to all concerned. This matter will receive more detailed attention in a later chapter.

Prior to the War the practice of grading foodstuffs under a National Mark was making very satisfactory progress. The customer who purchased foodstuffs marked in this manner could be assured of the best quality at all times. It is to be hoped that, as soon as conditions allow, a grading system will be reintroduced and even extended. The scheme could well be drafted to cover premises as well as foodstuffs produced therein, together with the methods of handling employed. At the present time only milk is graded in this manner. There appears to be no adequate reason why cafés and restaurants should not be graded, as this system has been widely used and has made considerable progress in the United States of America. This method of dealing with both individuals and premises might prove embarrassing at the outset, but there is little doubt that its adoption would provide a much-needed stimulus.

CHAPTER IV

FOOD POISONING

Introductory

It has already been stated in the Foreword to this volume that food hygiene covers a very much wider field than is represented by the prevention of food poisoning. It is none the less a fact that food poisoning remains the most obvious and immediately serious result of careless methods in the handling, preparation or serving of food. It is impossible to state how many cases of food poisoning occur in this country each year. Although food poisoning is notifiable, it is quite certain that many individual cases escape notification. It frequently happens that patients do not seek medical advice ; in other cases the medical practitioner does not notify the local medical officer of health. The information at our disposal is thus incomplete, although it is generally assumed that cases of food poisoning have definitely increased since pre-war years. Although scientific proof may be lacking, we can at least be sure that the problem merits very serious consideration. It is known that the number of *outbreaks* of food poisoning reported in England and Wales has risen from an average of approximately 80 before the war to 550 in 1944, and to 2,431 in 1949. In this connection it should be stated that the 2,431 incidents reported during 1949 were based upon a new system of reporting which combines and correlates the information collected by the Ministry of Health and Central Public Health Laboratory Service. This apparently significant increase may therefore be due in part to the more accurate and stringent reporting of outbreaks which has resulted, *inter alia,* from nation-wide publicity and increased knowledge of the problem. This explanation, however, cannot be accepted as telling the full story. The picture—and it could scarcely be described as a happy one—remains one of rising infection and morbidity which calls for serious and immediate attention.

The reasons for the increase in recent outbreaks of food poisoning are reasonably clear.

The *lowered standards of personal hygiene* which inevitably accompany a great war, and which have still to be fully re-adjusted, have very possibly contributed towards this increase. The *marked increase in communal feeding* which was first manifested during the war years, with the accompanying rise in canteen establishments, represents another factor of practical importance. As a corollary, the *number of individuals who now have to dine out* in order to assist the household rations must be borne in mind. In this connection it need scarcely be emphasised that the greater the number of people at risk the more danger is there of untoward results. Thus, as has recently been stated, the problem has changed from familial to communal, with results which might have been expected.

The third factor of definite significance is the *increase in made-up foods and prepared dishes* of the types which are particularly prone to bacterial multiplication. Associated with this phase of the problem is the fact that " scraps " are no longer discarded, but are saved for inclusion in later meals.

These three factors are generally held to be collectively responsible for the substantial increase in food poisoning which has shown itself in these islands over the past ten years. It would be difficult to place them in order of priority. They are all three inter-related and should be considered as complementary facets of one integral problem.

As stated above, one must always be careful to differentiate between *outbreaks* of food poisoning and *sporadic cases*. Due to the fact that more people nowadays eat *en masse*, it may be that the number of outbreaks has increased at the expense of individual cases. As Dr. Charles Cockburn has recently shown, however, this has not yet been proved. It is regrettable that more accurate information is not available as to individual cases of food poisoning. In this connection it would appear that a tightening-up of existing regulations is required, especially in the direction of more complete notification of cases by general practitioners and hospitals to Public Health Departments.

CLINICAL TYPES OF FOOD POISONING

The clinical types of food poisoning commonly met with in this country are set out in table form below :—

Infecting Agent	*Incubation Period*	*Duration of Illness*
Metals or chemicals	15 to 30 minutes	2 to 6 days
Staphylococcal enterotoxin . .	2 to 6 hours	6 to 24 hours
Indeterminate group (anaerobes, etc.)	9 to 18 hours	6 to 24 hours
Salmonella group	12 to 24 hours (up to 48 hours)	1 to 3 days (up to a week)
Dysentery group	1 to 3 days	2 to 6 days

Metallic or Chemical Poisoning

Many chemicals and metals which have accidentally obtained access to a particular type of food have been the cause of illness when present in excess. The most common types of metals responsible for metallic food poisoning are lead, arsenic and thallium, although various other metals which may obtain entrance to food may also be implicated. Lead poisoning is much less common nowadays than earlier in the century. The use of lead pipes in connection with soft-water supplies, with the related plumbo-solvent action, should, however, be remembered. Lead dyes may be found in foods prepared by certain processes embodying the use of such dyes, while the use of lead containers constitutes a further danger. Mineral waters exposed to lead or beer which has been drawn through lead pipes should also be viewed with suspicion. Arsenic may be present, particularly in the case of fruit, as the result of spraying fruit trees with a liquid of which this substance may be one of the main constituents. Some years before the War apples were placed on sale in this country which had been treated in this manner. A substantial number of cases of arsenical poisoning resulted. Numerous warnings against the use of such fruit in an unpeeled condition were issued by the Ministry of Health and by public health authorities. About the same time an outbreak of arsenical poisoning, with beer as the vehicle, was reported from a southern county. Arsenic is also used for the processing of certain foods, and may thus obtain entrance if used in excess. Although no fatal cases have been reported from this source, the possibility should always be borne in mind.

The use of enamelled and galvanised containers for acid foods has resulted in cases of antimony and zinc poisoning. The growing practice of disinfecting certain types of foodstuffs with ethylene oxide or hydrogen cyanide as a protection against infestation should be noted. The presence of these materials in excess, due to inadequate ventilation after treatment, must not be overlooked. Aluminium, tin or chromium are not usually present in quantities sufficient to cause illness, even when vessels manufactured from or containing these materials are used as food containers. Although tin is not normally regarded as toxic, the tinfoil wrappings used for certain types of food, particularly processed cheese, may affect the foodstuff. If direct contact is made with the actual food an excessive quantity of the metal may be present on the external surfaces of the article concerned. The presence of tin in excessive quantities is also an indication of unsatisfactory methods of preparation. Metallic or chemical poisoning is characterised generally by nausea, vomiting, diarrhœa, thirst and cramps. The patient's pulse is weak, breathing is shallow, and there may be cyanosis, convulsions and eventually coma. Symptoms, which vary to a greater or lesser degree with the metal or chemical responsible, very often occur within a few minutes of the contaminated food being consumed.

As illustrating the manner in which food may occasionally be contaminated by metallic or allied substances, an unusual case of food poisoning, reported by Dr. C. H. T. Wade, Medical Officer of Health, Borough of Prestwick, may be instanced. This outbreak affected two brothers who consumed veal which had been kept in a refrigerator in which penicillin and other drugs had been stored. The rubber cover of a bottle previously containing penicillin had been dislodged. The bottle itself had tipped on one side, allowing the contents to drip on to the food below. The remaining contents of this bottle were analysed and were found to contain Atropine Sulphate 0·8 per cent. The two brothers were found to be suffering from atropine poisoning, and made a satisfactory recovery after prompt treatment. In this connection it might be stated that the Pharmacy and Poisons Act forbids the storage of atropine preparations above food. It might also be observed that a portion of the veal consumed by the two brothers was offered to the domestic cat. Displaying greater acumen than its masters, this sagacious animal refused the invitation !

Staphylococcal Food Poisoning

Two types of *staphylococci* are at present known to be definitely capable of producing food poisoning. These are the coagulase-positive and bacteriophage types 6/47 and 42D. Very great advances have been made within recent years in the typing of staphylococci. This is done either by the phage method or serologically. This typing is extremely useful in tracing the origins of an outbreak of food poisoning due to the staphylococcus, and has resulted in much more accurate information becoming available. Staphylococcal food poisoning has a short incubation period. The duration of the resulting illness is seldom more than twenty-four hours, recovery being normally rapid. This type of food poisoning can be suspected when a number of individuals who have consumed the same food are taken ill, apparently seriously, within a short time of consuming the food. Symptoms include severe prostration and very often giddiness, the illness resembling acute sea-sickness. As already noted, recovery is usually rapid except in cases of elderly or debilitated patients. The fact that the staphylococcus can produce a heat-resistant toxin must also be borne in mind.

Indeterminate Group

The *indeterminate group* of food poisoning is a comparatively recent addition to the types of poisoning met with in this country. As the name implies, the group covers a variety of reactions which may be caused by a number of different organisms or toxins. Food poisoning due to streptococci, paracolon bacilli, and anaerobes, especially *Clostridium welchii*, are included in this group, as are also certain illnesses attributed to food in which the responsible organism or toxin cannot be traced. *Cl. welchii* may be present in enormous numbers in foods causing poisoning, multiplying with great rapidity. Symptoms are seldom severe and rarely last more than twenty-four to forty-eight hours.

Salmonella Food Poisoning

The salmonella type of food poisoning forms the largest group of food-poisoning cases met with in this country. Our opinion of and attitude towards salmonellæ have changed considerably since the classical work of Savage and White in the middle 1920s.

Salmonellosis, the name recently applied to the reactions which can be produced in the human body by salmonellæ, although those caused by *Salm. typhosa* and the paratyphoid bacilli are known as enteric fever. For present purposes, however, we can well confine ourselves to the acute type of food poisoning which can be caused by salmonellæ. The salmonella is a parasite whose host is normally a mammal, reptile or bird. It can produce endotoxins, and does so in its host. For many years it was considered that the only way in which salmonella infection could affect a human being was by the consumption of food which contained salmonellæ in sufficient quantity to produce the signs and symptoms of salmonella food poisoning. The human "carrier" of salmonella infection was not credited with any very great importance. For this reason, it was thought that epidemics of salmonella food poisoning could rarely occur, the problem being confined to individual cases or to isolated outbreaks in which each case had been originally infected from the same foodstuff. Thus the possibility of case-to-case spread was more or less eliminated. Although our knowledge of the salmonella group is still incomplete, this view is no longer tenable. It is now known that human "carriers" of salmonellæ do exist, and that they are capable of spreading infection. It would thus appear that at least some members of the salmonella group which were previously only responsible for elaborating toxins in selected hosts other than the human body may have evolved into human parasites. It may be that some form of mutation is taking place between parasite and host and that the salmonella group as a whole is undergoing changes comparable with those observed in other bacterial groups. It is certainly a fact that the salmonellæ responsible for typhoid and paratyphoid fever are capable of development in the human body, and that the human "carrier" is a very potent factor in the spread of these diseases.

Mention should be made of the valuable contribution to our knowledge of the salmonella family made in 1950 by Grant. Dr. Grant's observations warrant careful study, indicating as they do the changing phases of a truly significant problem.

The most common member of the salmonella group responsible for acute food poisoning in this country is *S. typhi-murium* (Aertrycke). *S. enteritidis* (Gærtner) is also quite frequently found, while more recently

S. newport and *S. orianienberg* have been associated with outbreaks of salmonella food poisoning.

As already stated, salmonellæ are parasites normally associated with mammals, reptiles and birds. The pig and the duck are particularly liable to be affected by the invasion of salmonellæ, while rodents are a significant source of infection. This points to the need for scrupulous care in the control of vermin.

Quite recently, Cruikshank and Williams Smith have demonstrated that cats, dogs and pigeons can excrete salmonellæ in their fæces. *S. newport*, *S. typhi-murium* and a salmonella of doubtful identity were isolated from the dogs examined ; the cats showed *S. typhi-murium*, *S. anatum*, *S. orianienberg* and *S. paratyphosa B*. The only salmonellæ isolated from the pigeons was *S. typhi-murium*. These types are all capable of producing disease in man. Although only a small percentage of the animals examined were found to be excreting salmonellæ (dogs, 1 per cent. ; cats, 1·4 per cent. ; pigeons, 2·25 per cent.) it would appear that domestic pets are worthy of consideration as possible sources of salmonella infection in man.

The normal incubation period in salmonella food poisoning may extend up to forty-eight hours. The illness may be severe, or even fatal. In mild cases, symptoms disappear within two to three days, seldom lasting for more than a week. Note must also be taken of the fact that symptomless excretors are a feature of salmonella infection. Such excretors may have suffered from a very mild form of food poisoning with virtually no symptoms ; others may have picked up the causative organisms, which they continue to excrete for a varying period without having reacted pathologically to it. Remembering the fact that the salmonella group of food-poisoning cases is the largest with which we have to contend (the Keuffmann-White Schema, 1951, lists 217 separate varieties), and also bearing in mind the vast increase which has been made to our knowledge of salmonellæ, it is highly desirable that we should apply this knowledge to the task of minimising or even eradicating this danger to man.

Dysentery Group

The dysentery group commonly met with in this country comprises cases due to *Shigella sonnei* and Flexner organisms. Of these, Sonne dysentery is much more prevalent.

Sonne dysentery has been present in this country for some considerable time and occurs in very large epidemics. It is one of the most infectious of all illnesses, and will rapidly pass through a school, day nursery or other type of closed or semi-closed community. Recent experiences in various parts of England show how rapidly the infection can pass from one school to another, pointing to the need for strict precautions as soon as an outbreak has been diagnosed.

When dealing with an outbreak of Sonne dysentery in a school, the exclusion from school of *all* the children in a family in which a case has occurred, or from which a positive contact has been reported, is to be recommended, no matter what school the remaining children in the family happen to attend. This will lessen the danger of spread of infection from one school to another. All such contacts should be excluded until every member of the family concerned, including adults, have given at least one negative fæces result. One of the difficulties in dealing with an outbreak of Sonne dysentery is the extreme mildness of the symptoms. As mortality is very low except in the case of elderly or debilitated persons and in young infants, the disease causes little alarm among the families affected. Parents and patients often fail to understand the need for the precautionary measures recommended and are too often apt to treat the whole matter in a cavalier fashion. None the less, Sonne dysentery can present a major problem to a local public health department and may involve the staff and laboratory service in very considerable work.

In considering diseases produced by the consumption of food one must also remember that conditions such as *tuberculosis, undulant fever, scarlet fever, tonsillitis, brucellosis and diphtheria* can be spread in this way. In the case of the diseases mentioned above, raw milk is sometimes responsible. Such diseases are not, however, strictly comparable with the more classic types of food poisoning, although the possibility of their occurrence should be borne in mind.

Although *typhoid* and *para-typhoid fevers* are caused directly or indirectly by the consumption of infected food, here again neither of these diseases is usually regarded as coming within this category of acute food poisoning. It will suffice to state here that typhoid fever (causative organism—*Salmonella typhosa*) is most often caused in this country by the consumption of water, milk or a milk product, usually ice-cream. Shell-fish or water-cress may also be implicated. The human " carrier " and excretor play a most important part in the spread of this disease. Paratyphoid fever (causative organism—*Salmonella paratyphosa B.*) is a parasitic infection and is commonly spread by human " carriers " and excretors and by infected foodstuffs. Mention is made of these two diseases when dealing with the various types of foodstuff which have been concerned in producing outbreaks or individual cases.

Mention might also be made of the very fatal type of *gastro-enteritis* affecting infants. Although the mode of spread of this virulent type of infection has not yet been fully elucidated, it is almost certainly an acute type of food poisoning in the strict sense. Precautionary measures are almost wholly confined to the need for the highest possible standard of cleanliness as regards attendants and utensils.

Botulism

Botulism, although rarely met with in this country, is a form of virulent food poisoning, of which notice must be taken. This disease is caused by toxins produced by the organism *Clostridium botulinum*. *Cl. botulinum* is an anaerobe growing in a variety of foodstuffs from which air has been excluded either by canning or by other means. It is slightly proteolytic and produces a cheesy odour in foods after several days' growth. In meats, or in the presence of carbohydrates, gas is formed. The chief foods infected are canned meat or sausages, although canned fruit and vegetables have also been implicated. Home-canned foods are extremely dangerous in this respect, due to insufficient sterilisation, which prevents destruction of the organism's spores. Bacterial growth, with the formation of toxins, occurs in the can or jar. Commercially-canned food packed by reputable manufacturers is generally free from danger, although insufficient processing may accidentally take place. *Cl. botulinum* is a native of cultivated or virgin soils and in itself is harmless. It produces, however, powerful toxins, which are highly dangerous. This toxin is not heat-resistant. Infected foods can thus be rendered harmless within a few minutes by heating to 212° F. Types A and B are the most toxic strains. Any suspected food should be adequately heat-treated and should never be eaten until this has been done. The intra-peritoneal inoculation of mice and guinea-pigs is usually employed for identification purposes. The employment of alcohol or salt will inhibit the growth of the organism, whilst refrigeration will retard toxin development, although when infected food is warmed, toxin formation may rapidly occur. There is no danger from frozen foods, even when de-frosted, if such foods are consumed within a reasonable time, although improper handling may render all types of food dangerous if conditions governing development are favourable. Canned foods affected with the *botulinus* toxin are usually "blown," due to the formation by the organism of carbon dioxide gas. When cans of this type are opened the contents sometimes froth and bubble. The odour emitted by the contents is often obnoxious, while the material is usually soft or semi-liquid in consistency. This acts as a definite safeguard since such food is unpalatable, whilst its appearance and odour focus attention on the changes which have taken place. (Symptoms develop within twenty-four hours, death usually occurring rapidly.)

Parasitic Diseases

Illness may follow the ingestion of certain parasites which infect part or all of the foods consumed. One of the commonest parasitic diseases is *trichinosis*, due to the nematode *Trichina spiralis*. The consumption of infected meat, usually pork, in which the parasite is present in an encysted form in the muscular tissues will produce the disease, particularly if the food is consumed in an under-cooked condition. The cyst is dissolved in the stomach, the parasite entering the muscles. Although the mortality rate is not higher than 10 per cent., trichinosis can give rise to painful symptoms resembling acute rheumatism. " Measly pork " infected with *Tænia solium* causes tapeworm disease following ingestion of infected meat. The worms are usually confined to the intestines but may find their way into other tissues. *Tænia saginata* (" beef tapeworm ") is not quite so important. The usual cause of human infection is the consumption of infected meat which has been insufficiently cooked. Tapeworms are frequently found in various types of fish. Uncooked or partially-cooked fish can therefore be dangerous. *Amœbic dysentery* is caused by the parasite *Entamœba hystolytica*, which invades the walls of the large intestine and is passed out in the fæces. Contaminated foods, infected by the individuals who have handled them, are the main cause of infection, although flies which have fed upon contaminated materials may also cause infection. It has been reported from America that a substantial proportion of restaurant employees are infected with *Entamœba hystolytica*, while the rate of infection of the population is said to be considerably higher. In 1933 an explosive outbreak of this disease occurred in Chicago, affecting 1,409 persons. Parasitic diseases are not common in Great Britain.

Miscellaneous Sources of Illness due to Food

A number of plants elaborate chemical poisons. Various types of fungi resembling and eaten in mistake for mushrooms are frequently responsible for serious illness. *Green potatoes* and *rhubarb* have also been implicated in this form of poisoning, while the *milk* of cows which have eaten unsuitable herbs may cause a type of milk sickness. Certain *animal foods* may be poisonous at particular times of the year. *Venison* eaten in spring or summer may also cause gastric disturbance. It should also be remembered that the decomposition of meat and fish is more likely to occur during the summer months, and that additional precautions are necessary then. *Glass* would appear to be unimportant from the food-poisoning aspect, although numerous instances of the presence of particles of glass in packaged foods have been reported. If any trouble is experienced with extremely fine or powdered glass, little harm is likely to ensue as this material will probably become coated with food and internal body secretions and be rendered harmless. The Ministry of Health have reported that, in the case of 156 samples analysed, it was found that 113, or 72·4 per cent., contained small pieces of glass. Jams packed in glass jars contained the largest portions. Great care should be taken to prevent the possibility of glass splinters obtaining entrance to foods packed in such containers.

FACTORS AFFECTING FOOD POISONING

Four prime factors are involved in the causation of any case of food poisoning. These are: time, temperature, moisture and suitable food supply.

Time

Bacteria, being living organisms, require time to multiply.

As already noted, large numbers of pathogenic organisms must be present in any foodstuff before poisoning can result (the presence of non-pathogenic organisms need not here concern us). Bearing in mind the vast variety of pre-cooked dishes which are now eaten either in the home or in a café, canteen or restaurant, the significance of the time factor will readily be appreciated. This factor was very well illustrated in a food-poisoning outbreak which occurred in a Nottinghamshire mine in 1947. The workers in this particular mine operated a three-shift system and were supplied with pressed-beef sandwiches prepared in the colliery canteen. The first (afternoon) shift ate the sandwiches eight hours after preparation; none of the men were affected. The second (night) shift ate the sandwiches approximately seventeen hours after preparation; again no one was affected. The third (day) shift of some 500 men ate the sandwiches approximately twenty-five hours after preparation; most of the men went down with symptoms of acute staphylococcal food poisoning within a few hours. When the outbreak was investigated, it was found that one of the canteen workers who had helped to prepare the sandwiches had an uncovered septic cut on one of her fingers. Bacteriological investigation showed that the sandwiches were heavily infected with staphylococci, and that the same organisms were present in the cut on the worker's finger. Further experiment, using human volunteers, showed that approximately twenty-six hours had to elapse between inoculation and consumption before any symptoms of food poisoning could occur under these conditions. This outbreak clearly shows the need for the strictest precautions in the matter of cleanliness, as well as the fact that many hours had to elapse before sufficient bacterial multiplication had taken place to produce the necessary toxin. When it is remembered that one bacterium can multiply to more than two million in seven hours, the importance of the time factor will be even more significant. The actual estimated figures for the multiplication of micro-organisms, excluding any time lag, are set out on the next page:

1 organism can become	64	in 2 hours.
1 ,, ,, ,,	512	,, 3 ,,
1 ,, ,, ,,	4,096	,, 4 ,,
1 ,, ,, ,,	32,768	,, 5 ,,
1 ,, ,, ,,	262,144	,, 6 ,,
1 ,, ,, ,,	2,097,152	,, 7 ,,

Temperature

The temperature factor is equally important. Germs multiply best at body temperature. High temperatures will kill most organisms, although spore-bearers may not be destroyed. Very low temperatures will seldom kill organisms. Here, however, the important fact to remember is that low temperatures will retard the growth of bacteria, and will therefore prevent dangerous multiplication. This points to the need for the more extensive use of refrigerators and cold rooms. A refrigerator should no longer be considered a luxury. It should be regarded as a necessity in every house and should be exempt from purchase tax. More important still, all cafés, canteens, restaurants and the like should be provided with adequate refrigeration space and/or efficient cold rooms. Cool rooms are not sufficient ; the temperature of such rooms must be sufficiently low to guarantee the inhibition of bacterial growth. So far as refrigerators are concerned, it should also be remembered that the purpose of a refrigerator is to keep cold, or at least cool, food cold, *not* to cool hot food. Food should never be placed in a refrigerator while still hot. If this is done the interior of the food, especially meat, may never reach a sufficiently low temperature to inhibit bacterial growth, due to the rapid cooling and sealing of the outer surface. This practice will also have an adverse effect upon the efficiency of the refrigerator.

The importance of breaking down bulk fluids into smaller quantities must also be remembered. If this is not done, cooling may be seriously affected.

In relation to temperature, the use of the *hot plate* is significant. The temperature of the usual hot plate found in cafés, canteens, etc., may well be ideal for the growth of bacteria. Thus, if meat which has been pre-cooked is placed on a hot plate for approximately two hours, conditions favourable to bacterial growth will immediately be present. It must also be borne in mind that, while the temperature of the outer surface of food may be sufficiently low to prevent dangerous bacterial multiplication, the temperature of the interior may be dangerously high.

The effect of temperature on the incidence of food poisoning may be further gauged by the fact that approximately three-quarters of all outbreaks of food poisoning reported in this country occur during the period May to October.

Moisture

It is estimated that the moisture content of any food must be at least 10 per cent. before bacterial growth can take place. For this reason dehydrated foods are usually safe until water has been added. This is particularly important in the case of such foodstuffs as dried egg powder and custard powder. During the early war years the rapid and dangerous increase in food-poisoning outbreaks was first observed. An intensive investigation was carried out, particularly during the latter part of 1942 and during 1943. This investigation eventually narrowed the field to two potential sources of danger. Two events had occurred during 1942, which had never before taken place in these islands. Large numbers of American troops had arrived in Great Britain, and it was thought that these troops might have brought with them new organisms hitherto unknown. Further investigation eliminated this source. The second event which had taken place in 1942 was the arrival of substantial quantities of dried eggs. Many tins of dried egg powder were examined. It was then found that approximately 20 to 30 per cent. of all the tins examined contained salmonellæ, mainly *S. newport* or *S. orianienberg*, two organisms of the salmonella group hitherto virtually unknown in Great Britain. Later investigations tended to show that this was a significant source of the increased number of outbreaks. So long as the tins remained sealed bacterial contamination was seldom heavy enough to constitute danger. If the tins were opened and the powder decanted in a dried state, there was again very little danger. As soon, however, as water was added the necessary moisture was made available to the organisms contained in the powder. The moral here is obvious : if powder or dehydrated foodstuff is to be used, it should be cooked and eaten as soon as possible after reconstitution.

Type of Food

Germs, again like the human family, thrive best on certain foodstuffs. Broadly speaking, foods of a semi-solid consistency are most favourable to bacterial growth, regard being paid to the moisture content. Bread, fresh meat and fish, cereals, fats, cooked vegetables and canned products from reputable firms are seldom responsible for food poisoning. The most dangerous types of food, i.e. those in which bacterial multiplication most readily occurs, are set out below :—

(*a*) *Made-up meat dishes and cooked meat not eaten fresh*, such as pies, brawn, pressed beef, stews, sausages, etc.

(*b*) *Milk and milk products.* Synthetic cream, custard, trifles, layer cakes, fillings and jellies.

(*c*) *Gravies, soups and sauces.*

(*d*) *Ducks' eggs and dried egg powder* if not thoroughly cooked.

(*e*) *Uncooked food*, such as shell-fish, salads and watercress.

It is interesting to note that the ideas of the public in regard to dangerous foodstuffs seldom coincide with the actual facts. Bread and fish are constantly blamed by the public for food poisoning, although neither foodstuff is often implicated. Although it is a fact that the wrapping of bread is a progressive measure which should be encouraged, it is highly problematical whether such wrapping has any very great effect either way so far as acute food poisoning is concerned. Cases of Flexner and Sonne dysentery have certainly been reported from cut bread. In these cases the infection was passed from the individual responsible for slicing the bread. Apart from this, bread (whether wrapped or unwrapped) is seldom implicated in food poisoning, although it must again be admitted that the present practice of bread delivery leaves much to be desired.

Some years before the outbreak of war the dangers which can follow careless methods in a bakehouse were very clearly illustrated by certain occurrences which came to the notice of a local authority in the London area. In this particular bakehouse, as in many older type bakehouses, the bread came out of the oven so hot that it could not be readily handled. It was the custom in this bakehouse to slide the loaves along the bakehouse floor by foot. When the loaves arrived at the other end they had been sufficiently cooled to allow of stacking. This practice was bad enough but not so bad as something else discovered during an inspection. One of the bakehouse employees was suffering from pulmonary tuberculosis. He made little or no use of a handkerchief while coughing and exhibited the even more deplorable habit of spitting on the floor. When a batch of loaves from this bakehouse was examined in the laboratory, live tubercle bacilli were discovered implanted on the lower crusts. It is scarcely likely that conditions such as those described above are common to-day. None the less, the fact that they did occur illustrates the need for scrupulous care and supervision. As a further instance of the need for constant supervision, one of the authors was very recently asked to examine a loaf in which small scraps of metal were embedded, presumably from the wrapping machine.

Fish, which is almost invariably washed when it reaches the home and thoroughly cooked, is not a serious source of danger. Unfortunately, retail fish shops often emit an unpleasant odour during the summer months and, where the fish is exhibited for sale on uncovered slabs, attract flies and other insects in large numbers. This is generally seized upon by the public as an instance of dangerous unhygienic methods which have been overlooked by the local authority. As noted elsewhere, a useful purpose can be served by enlightening the general public as to the types of food which constitute the greatest danger, and by explaining in simple language the necessary precautions which can and should be taken especially where made-up dishes are concerned.

The fact that semi-solid foodstuffs are particularly liable to produce food poisoning is well exemplified in the case of *synthetic cream*. This commodity is much more dangerous than milk, if one excludes tuberculosis from consideration. As regards *eggs*, the danger from ducks' eggs as compared with hens' eggs might be mentioned. The duck tends to lay her eggs wherever she feels disposed, very often among dirt and filth. The duck herself is not a clean animal and is a known reservoir of salmonellæ. Thus, salmonellæ may be present in the interior of a duck's egg or may be found on the shell. In order to ensure complete safety, ducks' eggs should be boiled for a minimum of fifteen minutes.

As has been stated, the four factors mentioned above must be present before a case of food poisoning can occur. If at any point the cycle is broken, the danger will be considerably lessened, and will probably disappear. The importance of at least two of these factors was well illustrated in an outbreak which occurred in a Southgate secondary grammar school in 1950. A consignment of salt beef was sent to this school, to be used for the midday meal. Normally, salt beef is not a particularly common source of food poisoning, owing to the fact that it is stored in brine of a reasonably high concentration. This should theoretically discourage bacterial growth, but does not always do so, probably owing to the fact that this type of beef is very often subject to extensive handling and also to the possible variations in the brine concentration. It so happened that another school in the same district had received a consignment of the same beef on the previous day and had reported that complaints as to its toughness had been received. The canteen supervisor of the secondary grammar school in question therefore decided to cook the beef, store it overnight and serve it cold the following day with salad. The beef was cooked for more than three hours in large vats. As a previous outbreak of food poisoning had occurred at the same school approximately twelve months before, and as the canteen supervisor had been warned not to leave the beef in the fluid in the vats overnight, the cooked beef was removed to a cool larder, where it remained until the following morning. During this time bacterial multiplication continued. Within twelve hours of consuming the midday meal upwards of 300 children and staff were affected, complaining mostly of diarrhœa and abdominal pain. Temperature and headache were also present in a number of cases. Bacteriological investigation showed that the beef contained large numbers of *Cl. welchii*, the spores of which had apparently escaped destruction during the boiling process. This outbreak is particularly interesting as showing the joint importance of the time factor and also of storage under inadequately cold conditions. It may be stated that the hygienic arrangements in the canteen affected were beyond reproach.

INVESTIGATION OF CASES OR OUTBREAKS OF FOOD POISONING

The measures to be taken by a medical officer of health in investigating a case or outbreak of food poisoning are very largely dependent upon the information he originally receives, usually from the general practitioner. Speed is the essence of success. Valuable initial time may be wasted in obtaining specimens of suspected food. This should, of course, be done in all cases, but the value is considerably lessened if the infecting organism is still unknown. Identification of the organism can be more fully carried out by the collection of specimens of fæces, vomit, etc., from patients. It is here that speed is important, as patients have very often recovered within twenty-four hours and may be averse to supplying information or specimens, especially if the patient is under the impression that he or she may be in some way incriminated. Specimens of fæces, etc., are, of course, still valuable several days after a patient has recovered.

In the case of a suspected outbreak, the medical officer of the local authority and his staff must work in close co-operation with the Ministry of Health and its laboratory service. As soon as the possibility of a particular food being at fault is suspected, a detailed investigation into the conditions under which the food has been prepared and sold should be made, samples being obtained for bacteriological and chemical examination. The sale of the suspected food should be stopped immediately ; any unconsumed portions already sold should be recovered, if at all possible. As the resultant illness may occur several—even many—hours after the food concerned has been eaten, it may not always be possible to obtain samples for examination, the remains of the responsible meal having been cleared away and disposed of entirely. Difficulties can also arise owing to the fact that the affected persons may have returned to their own homes, where the doctor in attendance may not have realised the importance of obtaining samples of vomit or fæces for examination. It is advisable to secure samples of *all* foods available in addition to those which are suspect, as quite often unsuspected materials may be at fault. This is particularly important in the case of attacks in which inorganic poisons are under suspicion.

An epidemiological inquiry should always be made before attention is paid to environmental conditions, since there is seldom any tendency for an outbreak to continue after the first attack is at an end. It is important that all available food materials left over from the suspected meal should be listed, as well as all persons present. A clinical history of each person attacked should be obtained as soon as possible. It should always be borne in mind that what may appear trivial details can be important. Every detail should therefore be noted immediately, as it will often be found that accurate recollection of the necessary details may be impossible if some time is allowed to elapse. Inquiries should be commenced immediately. It is neither necessary nor desirable to await the information supplied by the laboratory reports, as many supplementary details may be filled in later in the light of such reports. When the suspected food is prepared or sold in premises outside the area in which the cases have occurred, the place of production or sale should be noted and information passed to the Ministry of Health. This information should include full details as to manufacturer or distributor, the food involved, the method of transport, the date of production and distribution and the quantity concerned. The local authority in whose area the premises involved are situated should receive similar information.

When an inquiry is undertaken, information should be obtained on the following lines :—

(1) The food eaten at the suspected meal prior to illness.
(2) Date and place of purchase.
(3) Where stored and how prepared and handled.
(4) Condition at time of purchase and when eaten.
(5) Possibility of contamination in the home.
(6) Symptoms and diagnosis of medical attendant.
(7) Any prior illness in family.

As regards the point of production and distribution, the information required is :—

(1) The quantity of suspected food prepared and sold and whether or not the whole quantity can be accounted for.

(2) Complaints from other customers.

(3) Have investigations at premises given any indication as to the possible sources of infection or mishandling?

(4) Methods of preparation and handling at the point of production and distribution.

(5) Cases of illness amongst those handling the food.

The *collection of the materials* required for examination is extremely important. Samples of any remaining portions of food implicated should be obtained, even if this means the removal of fragments still adhering to the internal surfaces of containers or traces attached to wrapping papers. If this is not possible, samples should be obtained from the same batch of food or from the ingredients used in preparation, although in such cases the results may not be quite so satisfactory. In the case of canned or potted foods, the containers with the labels attached should always be collected.

In addition to samples of the food involved, pathological material from patients should be obtained wherever possible. Fæces or rectal swabs are extremely important. Samples of urine may also provide useful information in the case of chemical examination. Vomit should be sent for examination if obtainable. When a case proves fatal, portion of the small and large intestine, the spleen, the liver and kidneys should be obtained following a post-mortem examination, whilst the intact stomach will prove valuable should metallic poisoning be suspected. Samples of blood for serological investigation should not be collected unless seven days have elapsed since the onset of the illness. Thereafter the agglutinins should have fully developed and can be investigated serologically.

The *packaging and transmission* of samples for examination is extremely important. All materials collected for this purpose should be placed in cold storage if any delay in despatch is likely to ensue. The quantity of excreta obtained in sampling need not be large. In dealing with fæces, a throat swab dipped in the fæces will provide a satisfactory specimen provided the specimen contains sufficient mucous. Clean wide-mouthed, well-stoppered bottles should be used for all specimens ; samples of food should always be transmitted in a sterile container. If organs are to be sent for examination, they should be wrapped in a clean cloth which has been previously wrung out in a 30 per cent. solution of glycerine. Cold storage during transport may present difficulty, but this can be at least partially overcome by enclosing the specimens in a biscuit box filled with ice. The box and its contents should then be placed in a wooden box filled with sawdust in order to provide suitable insulation. Transmission should take place by the most speedy means of transport available. Specimens for bacteriological examination should not be sent by post unless no speedier means of transport is available.

The *laboratory methods* involved in the examination of specimens naturally vary. The test to be applied must obviously have close relation to the information supplied to the laboratory concerning the clinical background, where such exists. In all cases the information supplied to the laboratory should be as detailed and as accurate as circumstances will permit. In the case of food-poisoning outbreaks, samples are normally subjected to three forms of examination.

The *physical examination* usually presents least difficulty. Samples may be examined either macroscopically or microscopically, particular attention being paid to appearance, odour, colour and texture. Any obvious abnormalities may be of considerable assistance to the investigator. If the evidence appears to indicate that the poisoning is not of bacterial origin, the samples should normally be sent for *chemical examination* to the nearest public analyst. Almost all the common chemical poisons can be placed in three main groups. These are as follows :—

Group 1. Poisons which are volatile without decomposition when distilled with steam from an acid solution of tartaric or sulphuric acids.

Group 2. Non-volatile substances which do not distil with steam from an acid solution.

Group 3. Metallic poisons.

The *bacteriological examination* of suspected foodstuffs and pathological specimens is particularly important. In this connection it is important that the bacteriologist should be consulted as to the specimens required.

It is essential that the results of any examination carried out should be properly interpreted. The presence of organisms of the salmonella group in a suspected food is suggestive of salmonella infection, as these organisms are never present under normal conditions in foodstuffs. In the case of *Staphylococcus aureus* it is reasonably safe to assume that a heavy growth indicates that these organisms are implicated in the outbreak under review. The examination carried out in the case of suspected botulism provides direct evidence as to its presence. If any unusual organisms are present in foods which appear to be implicated in an outbreak of food poisoning, they should always be suspect until the bacteriologist has reported that they are non-pathogenic. In considering the suitability or otherwise of any food for human consumption it is important to remember that the methods of production and handling, together with the bacteriological and chemical reports, should be considered as a whole.

Ministry of Health Memorandum 188/Med., revised in 1949, sets out in detail the steps to be taken in England and Wales by medical officers of health in the investigation of food poisoning. This booklet should be carefully studied by all concerned, as a standardised form of investigation presents obvious advantages. The Memorandum includes, as an Appendix, a summary of the details required by the Ministry of Health in relation to food poisoning outbreaks. A copy of this Appendix is set out below :—

"APPENDIX A *

HEADINGS OF INQUIRY INTO OUTBREAKS OF FOOD POISONING

1. Extent of Outbreak

By means of visits to affected households, institutions, etc., by inquiries of medical practitioners in the area and of neighbouring medical officers of health, a complete list of cases (notified or otherwise) should be prepared, giving ages and occupations.

2. Clinical Features of Illness

In each case a note should be made of the date and hour of the first symptoms, the nature of the initial and subsequent symptoms, their severity, their duration and whether accompanied by fever or followed by the development of physical signs of lesions of the central nervous system.

3. Evidence Implicating Particular Food

There should be made :—

A note of the date and hour at which suspected food was consumed by each affected person.

A note of persons at risk by consumption of suspected food but remaining unaffected.

A note of persons taken ill at the same time who did not consume suspected food.

4. Identification of Agent Contaminating or Infecting Food

Consideration should be given to: (*a*) the type of agent which is suggested by the clinical features of the illness and the interval between consumption of the suspected food and onset of symptons (see Appendix B attached), also to the properties of the suspected food as a culture medium for bacteria ; (*b*) success or otherwise of attempts to isolate suspected agents from samples of suspected food.

5. Source and Means of Contamination of Food by Chemical or Bacterial Agent suspected

The source suggested by the epidemiology of the outbreak, i.e. its extent, the grouping of cases, origin and distribution of suspected food, etc.

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The circumstances associated with the preparation, storage and distribution of suspected food.

A history of previous or current illness of a significant kind in persons associated with preparation and distribution of suspected food.

The results of laboratory tests on persons associated with preparation and distribution of suspected food."

The Ministry of Health also requires from medical officers of health an annual return of cases of outbreaks of food poisoning which are known to have occurred in the area under their control during the past year. The report must be submitted in standardised form and should include copies of any special reports submitted to committees, councils, etc.

Visits to canteens, restaurants, etc., and interviews with staff concerned should be carried out by the medical officer of health or his staff and the laboratory working as a team. Co-operation in such cases is essential. This is much more likely to have satisfactory results when local officials, already known to the individual concerned, break the ice, so to speak, and introduce the laboratory representatives as part of the team. The medical officer of health and the laboratory should each know what the other is doing and should work together from the earliest possible moment.

PREVENTION OF FOOD POISONING

Although the prevention of food poisoning receives attention throughout this book, it might be well to summarise the preventive measures available. These might be stated as follows :—

(*a*) Education of Food Handlers

In the education of food handlers, of whom there are many thousands in these islands, lies our greatest hope for the future. To be of any use this education must be continuous. It may possibly be reinforced by large meetings, but it must always be remembered that one meeting is never sufficient. Sanitary inspectors are usually good educators and should be given the opportunity of gaining sufficient knowledge and confidence to carry out this important work. As noted elsewhere in this volume, the appointment of food sanitarians, such as are employed in the United States of America, might be an advantage.

Many large commercial firms dealing in foodstuffs are well aware of their vital responsibility, and have taken steps to educate their staffs in the proper measures. The firm of Marks and Spencers might be instanced in this connection. This firm has produced an excellent film strip, and an equally admirable volume, on food hygiene. Both the film strip and the handbook are designed to appeal to employees of limited education and background. This example might well be followed throughout the country. The part which hygienic food traders' guilds can play in education is discussed in more detail in Chapters XXVI and XXIX.

There can be no doubt that, without proper education of the food handler, little progress can be made in safeguarding our food supplies. This fact cannot be too often stressed nor receive too much attention.

(*b*) Cleanliness

The washing of hands by food handlers after using the W.C. is one of the most important single factors associated with food poisoning. This practice should be taught as an essential social habit. If it became universal, there is little doubt that food poisoning would decrease. It is an unfortunate fact that several of our national newspapers have so far refused to accept advertisements supplying this very excellent advice. One is at a loss to understand this attitude, which can only be deplored. Several local authorities have recently provided free washing facilities in their public conveniences, either to the public as a whole or more specifically to food handlers. This is an excellent step in the right direction which one would like to see extended. It is surely illogical to display notices in public conveniences inquiring whether the user has washed his or her hands and then to charge 3*d*. for the privilege. It is equally important to ensure that adequate washing facilities are available in all establishments where food is cooked, prepared or served. Such facilities should be provided in the most convenient place so that the act of washing the hands will be made as easy as possible to the employee. It is also very important to ensure that an adequate supply of hot water, soap and towels is provided. Too often one sees the wash-basin hidden away in the most inaccessible position ; equally often one has to deplore the absence of hot water and a clean towel.

The highest standards of personal hygiene must be maintained at all times by food handlers. Rules of conduct should be laid down ; equally important, these rules should be constantly and rigorously enforced. Dirty finger-nails, nose-picking and coughing or sneezing without the use of a handkerchief should be regarded as cardinal crimes and should warrant speedy dismissal. In no industry is the need for strict personal hygiene more clamant ; nowhere do the results tend to be more disastrous.

(*c*) Construction and Equipment

The construction, equipping and maintenance of food establishments are discussed in greater details in Chapters XXVI and XXVII. Suffice here to say that strict cleanliness at all times is essential. In this connection it might be stated that, contrary to popular belief, infection from crockery or cutlery does not normally constitute a grave danger. Unless gross contamination has taken place, organisms will not multiply to any appreciable extent on crockery or cutlery. Dirty crockery or cutlery is of most significance as an indication of the existence of conditions in the kitchen and elsewhere, which constitute a very definite danger, just as a slovenly waitress or dirty tablecloth point to an unsatisfactory establishment, in which discipline and care are obviously lacking. One must remember, however, that large food containers are a source of danger and should never be neglected during an inspection. The use of modern detergents and sterilising agents might also be mentioned.

(*d*) Rodent Control

Rodent control must be an integral part in any preventive scheme. Rats and mice provide a reservoir for salmonella infection and will readily contaminate food.

(*e*) Fly Proofing

It will scarcely be necessary to emphasise the importance of fly proofing. This is of particular importance during the fly-breeding season, in July and August. Although the protection of food supplies displayed for sale is vitally important at all times, it is unfortunate that adequate materials are not yet fully available to ensure this very desirable object. Until these materials do come on the market adequate improvisation should be insisted upon in every instance.

(*f*) Register of Staff

A register of staff should be kept in all food-handling establishments. This register will show absenteeism, and can be most illuminating. All employees should be instructed to report *illness* to their employer, so that the cause of the illness can be properly and speedily investigated. In the same way, all cuts, abrasions, etc., should immediately be reported and treated, an adequate first-aid kit being a pre-requisite in all food-handling establishments. In this connection it should be noted that a dirty bandage is just as dangerous as an open wound. Such bandages should be replaced by elastoplast or new skin dressings covered by a finger-stall. Dirty bandages are especially objectionable. When, as one of the author's recently discovered, such bandages can fall off and appear in cake purchased over the counter, their continued use by food handlers is to be deplored.

(*g*) Medical Examination of Employees

The medical examination of employees concerned with any type of food preparation or handling is important. Examinations of this type should be universally required. Indeed, there appears to be little purpose in requiring premises and foodstuffs to reach a specified standard if the efforts put forth are liable to nullification by the employment of unhealthy workers. Many countries now require that all persons employed in the food industry should be able to produce evidence of a clean bill of health at all times. It should be possible to ensure that all employees are medically examined at least once each year, preferably more often. They should be required to submit signed medical proof that an examination has been carried out when requested by the controlling authority. This is particularly important in the case of those persons handling food which may become easily infected, e.g. milk or prepared meat dishes. Up to the present the public health value of periodic medical examinations has either not been fully recognised or has been discounted on the grounds of cost and administrative difficulties. The necessary legislation should be provided to ensure that all employees be medically examined annually, that they be required to submit regular samples of fæces for bacteriological examination, and that they undergo Widal and Kahn or Wasserman tests at frequent intervals. Now that the National Health Service is in operation throughout the country, it should not prove too difficult to incorporate into it a scheme of the type suggested.

It must be admitted that any scheme of medical examination which does not call for *frequent* inspections leaves room for error, and will not provide any real guarantee of safety. There are some who hold that, for this reason, medical examinations are not only useless but produce a sense of false security. This is not necessarily the case. Provided it is properly interpreted and taken at its face value, all information relating to the health of employees is useful. This was proved by the medical inspection of Army cooks and by the welfare experiences of large food-producing firms. A means should be found which will allow of medical examinations at reasonable intervals, emphasis being laid on the collection and correlation of information relative to the individual's capacity to transmit infection. This can do nothing but good and should be an integral part of future legislation. The importance of *initial* medical examination in the case of food handlers, especially those handling susceptible foodstuffs or intimately associated with certain categories of food production and preparation, is particularly required.

It is fully appreciated that the medical examination of food handlers presents a series of difficulties, some of which it may not yet be possible to overcome. This particularly applies to staff employed in small establishments, where changes are frequent and a sense of full responsibility not always evident. This should not, however, be allowed to militate against a policy which may be a counsel of perfection but which none the less represents the ultimate standard at which we should aim.

The greatest obstacles to the removal of food poisoning as an immediate danger are ignorance and irresponsibility. Our main efforts should therefore be directed towards eliminating these potent sources of harm. Our aim must be to raise existing standards by education and by the enforcement of authorised regulations. Of these two alternatives, education most definitely presents the greater hope. Such education should begin at the earliest possible age, best of all in school or even before. There is no doubt that, if the future generation brought to its defence an awareness of the dangers, and an honest desire to conduct itself and its affairs in such a way as to reduce practical risks to a minimum, the future as it relates to food poisoning would be very much brighter than it is.

CHAPTER V

MEAT

Meat, a term applied to the flesh of cattle, sheep and pigs, is one of the basic foods of a considerable proportion of the human race. Prior to the late War, Britain was one of the largest meat-consuming countries in the world and the amount consumed was so great that the bulk of the nation's supplies had to be imported from abroad, the Argentine and New Zealand supplying most of the nation's requirements. The impossibility of supplying the needs of the population with home-produced meat made itself obvious when hostilities began in 1939. Owing to economic and other circumstances, the ration then imposed has been gradually reduced so that the quantity now available has fallen by almost 50 per cent. Even before the War, however, less meat was consumed in this country than during the previous century and the years which immediately followed. Owing to the increased variety of alternative foods available, together with changing tastes, meat consumption has declined steadily if not rapidly since the beginning of the present century. Rationing has brought about a further decline, which does not appear to have caused any very marked effect upon the health of the community.

The meat industry was originally a trade carried on by small local units. The village or town butcher purchased his requirements in the local cattle markets, brought the animals home and slaughtered them in his own slaughter-house, generally situated at the rear of his shop premises. In quite a number of districts this practice persisted until 1939. As the demand increased the production of meat outgrew the local facilities available and meat production gradually developed until it became one of the major world industries. The business of meat production and distribution expanded rapidly on highly technical lines and, as a result of an increase on scientific knowledge, became more dependent upon the selection of the best animals for slaughter. The application of improved technical methods of slaughter, storage and distribution was assisted by financial backing provided by commercial circles. As might be expected, the local butcher, who slaughtered and sold meat direct to his customers, wasted an appreciable percentage of the carcasses involved. It has been estimated that the edible portions of cattle and sheep amount to 50 per cent. of the whole, whilst approximately 80 per cent. of pig meat is available for use. The disposal of the remainder of the carcass was often extremely difficult. Research has now made available sufficient scientific knowledge to render most of the materials formerly thought to be useless capable of being utilised. Many of the large meat companies abroad make use of almost every part of the carcass, nothing likely to have a commercial value being wasted. This policy was carried out in this country during the war years and has been continued since hostilities terminated, in relation to home-killed animals. The same policy is likely to continue as a standard practice now that the former wasted materials can be efficiently salvaged.

Premises and Handling

The meat producer of the past was unable by reason of lack of suitable facilities to make full use of all parts of the carcass. Early in the present century, however, ideas were formulated in relation to improved methods for *slaughtering* animals for food. The reformers realised that the unhygienic conditions which in many instances obtained in private slaughter-houses were unsatisfactory. Many of the premises used were old and thoroughly insanitary, were situated in thickly-populated neighbourhoods, were difficult to keep clean, provided poor accommodation for slaughtering and storage, rendered inspection of the dressed carcasses extremely difficult and generally fell short of the standards considered desirable, indeed essential, in all food-producing premises. As a result, suitable abattoirs were designed. These abattoirs provided slaughtering accommodation at centralised points in each area and encouraged a more hygienic handling of meat. It must be admitted that progress in this direction was not quite so rapid as could have been desired, although many local authorities assisted these efforts by the erection of public abattoirs in which all slaughtering for the district concerned could be concentrated. This policy of centralisation was continued by the Ministry of Food at the commencement of the War, when most of the small, unsatisfactory private slaughter-houses were closed, the slaughtering of food animals being centralised in existing public abattoirs and in a number of the better-type private slaughter-houses which were considered suitable for the purpose.

The advantages derived from centralisation were numerous. Ante- and post-mortem examinations can be carried out with greater ease and efficiency, suitable storage for carcasses after slaughter is available, ease of access for incoming cattle and outgoing carcasses is provided, while it has been found possible to make much greater use of by-products. In addition, great improvement in hygienic conditions and handling has become possible, since everything is placed under expert supervision at all stages of production and distribution. It is still a fact, however, that many of the buildings chosen for centralised slaughtering were, and still are, quite inadequate for the number of carcasses handled. To this extent, the maximum improvement which might have been achieved has not yet become practicable. It is none the less likely that centralised slaughtering has come to stay and that the day of the unhygienic slaughter-house is over. Efforts should be made to improve or extend those premises which at present possess inadequate facilities. More settled conditions will doubtless enable this to be done.

The definite requirements of a slaughter-house are: (*a*) adequacy for the work to be undertaken, (*b*) suitable construction so that cleansing is simplified, (*c*) satisfactory drainage, and (*d*) an adequate and pure water supply. Entirely separate sections of the establishment are essential for handling the edible and inedible products. Adequate toilet and washing facilities are essential and must be properly used; whilst means for the cleansing and disinfection of all utensils, knives and the other implements employed must be provided, together with some means of sterilisation for those articles which are used in handling diseased carcasses. Nuisances from flies and rats should not be tolerated, whilst the personal habits of the employees should be watched carefully so that they conform to strict hygienic principles. No practices must be permitted which are likely to interfere with the purity of the final products. An obvious provision is a bacteriological laboratory, which should be regarded as essential for any up-to-date abattoir.

Once the animals have been slaughtered, their meat requires *transportation* to the various retail premises. The present methods employed leave much to be desired. It must be granted that the existing legislative requirements demand that methods of handling shall be satisfactory, but it is equally true to state that the transport vehicles employed cannot in many instances be considered as fulfilling those hygienic conditions which are so necessary in relation to the handling of food. Indeed, many of these vehicles are totally unsuited for the work. Meat is thrown into the vehicles, in many cases on to the bare wooden floor or on to heaps of straw which may be extremely dirty. No efforts appear to be made to ensure that all the vans employed are even clean. It is also a legal requirement that overalls and head coverings shall be worn by those persons engaged in carrying meat or in loading transport vehicles. This requirement is not regularly observed. Much meat comes into contact with the dirty clothing or hair of the persons engaged in the work. Even when overalls and head coverings are worn these are often in an extremely dirty condition. The practice of wearing blue or brown overalls is to be deprecated, as it is not possible to discern when these are becoming dirty. Considerable scope for improvement in the transport and handling of meat after slaughter exists. Steps should be taken to improve matters in this direction without further delay.

As in the case of premises used for the slaughter of animals, *retail butchers' shops* have made rapid advances so far as hygienic standards are concerned. The day of the old-time butcher's shop, with a slab filled with various cuts of meat and with the windows wide open to dust and dirt, has very largely gone. Even in most public markets meat is now suitably covered when sold from open stalls. Legislation has facilitated these improvements, but a great debt is owed to public health officials for their wide interpretation of indefinite legislation and for the pressure which they brought to bear on individual tradesmen and their trade associations to effect improvements. The result has been that windows are now kept closed. In the majority of cases one-piece windows which cannot be opened have been provided, so that it is no longer possible for one's name to be written in the dust which has settled on the window slab. There has also been a greater understanding on the part of the meat trader as to the need for improved methods of handling perishable foodstuffs. The out-of-date ice-box is rapidly disappearing, being replaced by electrically-operated cold rooms which have proved of inestimable benefit both to the trader and the customer. It is the practice nowadays to keep most of the meat in the refrigerator until it is sold, even during normal trading hours. This custom has resulted in an almost complete absence of flies, which once infested every butcher's shop and caused considerable spoilage of the meat. One point must, however, be borne in mind. Far too many cold rooms are not being maintained in that hygienic condition which should be the standard in all premises where food is sold. This point merits detailed attention by controlling officials.

Ante-mortem Inspection

The inspection of animals should begin before they have been slaughtered, as those which are ill are not only likely to be dangerous to health in themselves but may infect other animals or the dressed meat when slaughtered. This, however, is not always the practice. The pre-slaughter condition of animals allows symptoms which require a more rigorous examination after slaughter to be observed, while the unavoidable infection of persons handling such animals and their meat is prevented. Animals which are obviously

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diseased can be isolated and dealt with separately in a building set aside for this purpose. They can also be excluded from any insurance scheme which may be operating in the district. Affected animals may be isolated for observation purposes, while injured animals, those suffering from excessive fatigue, broken bones or overheating may be beneficially rested for a definite period before slaughtering takes place. In any event, animals should be rested for at least twelve hours before being slaughtered. This period might well be extended to three or four days if the animals concerned have travelled long distances. During the resting period water should be supplied in abundance and the animals induced to rest in order to rid themselves of any wasting due to recent activities. Resting allows bruises to heal, while the animals bleed better. The loss of weight in transport may equal 10 per cent. of the whole over twenty-four hours, a percentage which increases during hot weather. Fatigued cattle bleed badly when slaughtered and their flesh will not keep so well as that from rested animals.

Slaughter

After a suitable period of rest, animals should be slaughtered as speedily as possible in a humane manner. All animals should be stunned before they are slaughtered. In Great Britain it is laid down that this operation shall be carried out by mechanical means, an exception being made in the case of sheep and lambs. Adoptive bye-laws, enforcing the mechanical slaughter of sheep and lambs, are, however, available and have been brought into force in many instances. Most European countries require similar methods to be employed. Stunning renders slaughter more speedy, as the animal is quieter.

In the case of cattle there is less likelihood of cruelty such as may occur when a pole-axe in the hands of an inexperienced operator is used. At the outset objections were raised to the introduction of compulsory stunning, it being stated that the process would result in incomplete bleeding of the carcass. The accuracy of this contention is doubtful. Danger from accidents may arise if a gun which employs a free bullet is used, but to some extent this is nullified as almost invariably a gun which possesses a captive bolt is employed. After the animal is stunned, a pithing cane is introduced through the brain and is pushed for some distance down the spinal cord in order to destroy the medulla. The animal is then bled, a straight cut through the skin of the chest being made until the large blood-vessels situated at this point are opened. If the incision is properly made, blood will emerge in a strong stream. This liquid is usually collected for further use. If the blood is to be used for food purposes, it is very important that the neck of the animal, the knife employed and the hands of the worker should be clean. The liquid should be collected in a clean sterilised vessel. This vessel should be identified with the carcass by some method of marking so that, if the flesh of the beast is rejected as unsound, the blood will not be used for edible purposes. In the case of Kosher meat, the animal is not stunned but is thrown to the floor either by means of ropes and a pulley or a casting pen and the throat severed. With this method the animal is conscious until its throat is cut, while during the process it has to be roughly handled. The blood is wasted since the stomach contents become mixed with it.

Calves are stunned and suspended by the hind legs, the head being cut off in order to facilitate complete evacuation of the blood. In the case of *sheep*, a knife is inserted in the nape of the neck after stunning has taken place. The spinal cord is then severed. *Pigs* are stunned either with a captive-bolt pistol or, where large numbers have to be dealt with, an electrical stunner is employed.

Dressing

When the animal has been completely bled, it has to be dressed before becoming available for the retail market. In the case of cattle, the skin is removed and the organs severed from the body. The carcass is then split, trimmed and cleaned. Evisceration of the carcass should be carried out in a satisfactory manner in order to prevent more than the minimum of bacterial contamination. The openings of the alimentary canal and the bladder should be tied before these organs are removed in order to prevent any of their contents coming into contact with the meat. After removal, the organs should be deposited in a suitable place and should be readily identified with the appropriate carcass. Sheep and calves are dealt with in a similar manner. Particular care should be taken in wiping down carcasses after they have been dressed as in Essex during 1946, an infected pig carcass was wiped down with cloths which were used on, and subsequently infected, other carcasses. The result of this action was the contamination of a large amount of meat and 3,000 cases of acute food poisoning were notified with three deaths. It is, however, quite a common practice for the carcasses to be inflated with air prior to flaying in order, so it is stated, to assist in the removal of the skin and to improve the appearance of the dressed carcass. It is doubtful whether this practice does facilitate the removal of the skin. In any event it is most unhygienic. Inflation is usually carried out by inserting a pointed nozzle attached to a hand-operated air pump through an incision in the subcutaneous tissue, the air injected being distributed throughout the tissues by beating the carcass with a stick. From a hygienic viewpoint the entire process is most objectionable, as air is usually drawn from the floor level, where it is most likely to be contaminated. It was formerly the practice to inflate the carcass by means of the mouth. This unhygienic method is now prohibited. Inflated carcasses can be readily recognised by their unusual size and glistening appearance, whilst the tissues feel spongy and crepitate, or crackle, to the touch. As it is impossible on inspection to determine the method of inflation employed, the process should be prohibited on hygienic grounds.

After being stunned and bled, pigs are scalded in hot water, the temperature of the liquid being generally raised to the required level by means of steam injection. Soda is often added to the scalding water in order to assist in the removal of the bristles. Scalding water should be frequently changed, although this is not the usual practice.

Post-mortem Inspection

All meat should be inspected as soon as possible after slaughtering has been completed, although in certain instances the carcass may be left hanging for any period up to twenty-four hours in order that a final conclusive judgment may be more readily given. The blood and skin of the animal when removed from the carcass should be carefully examined. The general appearance of the carcass is also important. Any emaciation should be observed, whilst discoloration should also be noted. The external fat should be light yellow in colour and should be free from hæmorrhagic patches. The carcass should set in eight to twelve hours, rigor mortis being of great assistance to the inspector in forming his final judgment. After death the muscle plasma, which is a contractile, semi-liquid substance present within the tissues during life, coagulates and causes the body to stiffen. This coagulation results in the formation of myosin owing to the action of a ferment produced after death. As a result the tissues gradually become taut, sarcolactic acid being formed. Fresh meat is tough, but due to the formation of this acid it becomes soft and gelatinous and finally tender. Under normal circumstances the state of rigor mortis persists for periods which may vary from one to several days, but if an animal has been subjected to any muscular exertion immediately prior to slaughter its carcass may become stiff within a few minutes. When exhaustive or febrile conditions are present, more particularly in the case of septic diseases, rigor mortis is sometimes absent. The pleura, peritoneum and posterior surface of the diaphragm should be carefully examined, particular for signs of stripping of these membranes or for evidence of tubercular deposits. All bones and joints should be inspected. Where considered necessary, the various lymphatic glands should be incised for evidence of diseased conditions, while the head, tongue and glands of these portions of the carcass should not be overlooked. All the organs should be carefully examined and glandular incisions made to ascertain whether diseased conditions are present. The glands of the carcass and organs often show early signs of disease ; for this reason they are of great importance. Memorandum 62 (Foods) issued by the Ministry of Health lays down the principles and practice governing meat inspection, together with the judgments required in all cases of disease. These recommendations should be carefully followed. It should be emphasised, however, that they are only recommendations and possess no legal standing. It follows therefore that, if further legislation connected with meat inspection is contemplated, these suggestions should be reintroduced, perhaps with some additions or amendment, as a compulsory standard for inspection. All meat condemned for the presence of diseased conditions, or for any other reason which renders it unsuitable for human food, should be removed to suitable premises where it may be denatured and sterilised under steam pressure for sale as fertiliser or animal food. Rooms used for condemned meat storage should be separated from the main slaughtering and cooling rooms and should always be kept locked, the key being left in the care of some responsible official. The blood and organs should always be readily identified with the carcass to which they belong in order that inspection may be facilitated. Accurate records should be kept by the inspecting officials of the incidence of disease in the animals slaughtered.

Diseased Conditions

As is the case with all living organisms, food animals frequently suffer from physical conditions or diseases which may render portions or the whole of the carcass unfitted for human consumption. While it is impossible in a volume of this description to deal at length with each of these conditions, some general consideration must be given to them.

Certain *physiological conditions* may be noticeable on inspection. In the case of a badly-bled animal, the flesh of which undergoes rapid decomposition after death, the carcass is condemned. This is also the practice when dealing with immature or stillborn animals. A general poor quality of the meat does not in itself provide sufficient grounds for condemnation, particularly if the carcass is otherwise free from signs of disease. Nor does slight emaciation, if the animal is free from disease and is not badly emaciated. Carcasses of this type must be judged on their merits. Abnormal odours may be emitted by carcasses due to tainted feeding-stuffs, drugs or the absorption of taints from adjoining foul-smelling substances. In many such cases the smell is most pronounced when the carcass is warm. Roasting or boiling tests of suspected portions may be necessary before judgment can be pronounced. If the taint is marked and is maintained during storage, the carcass is usually condemned ; otherwise it may be used for human consumption. Any abnormal colouration of the carcass fat does not provide sufficient reason for the condemnation of the carcass if otherwise healthy in appearance. In the case of accidental death by choking, drowning, dystopia or suffocation, the condition of the meat usually renders condemnation necessary.

A large variety of *inflammatory diseases* may provide grounds for the condemnation of either a portion or the whole of the carcass and organs affected. These diseases are always accompanied by an elevation of the body temperature, so that the carcass may have to be condemned on account of the fevered condition of the flesh. In the case of chronic diseases it is usual to destroy the affected portion or organ if the flesh is otherwise sound. This applies to endocarditis, glossitis, hepatitis, if not in an advanced stage, necrosis, peritonitis, pleurisy and pneumonia. If, however, fever or septic conditions are present in addition to these diseases, and also enteritis, mammitis, nephritis and ostitis, the whole carcass may have to be condemned. In the case of fevered flesh, the carcass should be hung for a period of at least twelve hours before judgment is given, the general condition of the flesh, the degree of fever and its origin being taken into consideration. With many of the diseases outlined above either fever or septic conditions may have developed in varying degrees according to the progress of the disease. In such cases the whole carcass may require condemnation. Septic flesh is usually dark, flaccid and soapy to the touch, putrefaction being rapid. Fevered flesh and the affected organs are usually darker in colour than normal ; quite often numerous small hæmorrhages are visible within the substance.

Diseases of the blood usually demand condemnation of the entire carcass. This procedure is necessary in the case of anæmia, hydræmia or dropsy, marked jaundice, leucocythæmia and uræmia. In the case of tumour of the liver the whole organ should be condemned. In other portions of the carcass the affected part only is removed. When dealing with cases of rheumatism or rickets, the quantity to be condemned is based upon the general condition of the flesh and the degree of emaciation or poor quality present. In severe cases the whole carcass is destroyed. In swine livers a cirrhotic condition known as milk-spot is often present. If these are numerous, the affected organ is destroyed.

Degenerative conditions such as cloudy swelling, fatty degeneration and infiltration, together with melanosis, are not extremely important. It is seldom necessary to condemn more than the affected portion of the organ concerned.

The commonest diseases found in slaughtered animals are those due to infections of the *bacterial type*. Many such diseases, notably anthrax, black quarter, braxy, caseous lymphadenitis, glanders, malignant œdema, sheep pox and tetanus, are notifiable diseases under the Diseases of Animals Acts. The affected carcass and all its organs are condemned in every instance.

Actinobacillosis is judged on its severity. When a local infection is present, the affected organ only is condemned, as is the case with infections due to bacillary necrosis. In the early stages of calf diphtheria, Johne's disease, louping ill, swine erysipelas or urticaria the affected portion or the organ is condemned. Where dropsy is present, however, and where the disease has become acute, the entire carcass and organs may have to be condemned. Probably the most important bacterial disease affecting cattle and pigs, but rarely sheep, is bovine tuberculosis. The usual practice here is to condemn the affected organs or portions of the carcasses in localised cases. Where the disease has become generalised or when emaciation is present, the entire carcass is condemned. The disease is considered to be generalised when it is present in conjunction with miliary tuberculosis of both lungs, where the lesions are multiple, acute and progressive, where a number of lymphatic glands are affected and where the pleura and peritoneum together with the carcass glands are diseased. Congenital tuberculosis in calves also calls for destruction of the carcass affected. Efforts should always be made to trace the dam of the affected animal, with a view to her removal from the milking herd.

A number of cattle diseases are due to the *action of fungi or viruses.* Two of these infections, cattle plague and contagious pleuro-pneumonia, have not been seen in this country for some considerable time and, together with foot-and-mouth disease and swine fever, are the subject of immediate notification by special Order. Of the remaining types, malignant catarrh requires condemnation of the carcass ; actinomycosis the condemnation of the whole animal unless, as is usual, the disease is confined to the head and tongue. The affected lungs only are destroyed where there is an infection of aspergillus pneumonia.

In the case of *suppurative diseases* very great care should be exercised in giving a considered judgment. Many food-poisoning outbreaks have been due to the consumption of flesh of animals which have been suffering from diseases of this type. This possibility should always be borne in mind when dealing with such conditions. The simplest infection is bacterial endocarditis, in which only the heart need be condemned if the rest of the carcass is otherwise satisfactory. In dealing with other types of suppurative diseases, such as navel-ill or joint ill in calves, osteomyelitis, sapræmia, septic mastitis and metritis, the entire carcass and organs are condemned in every instance, as the flesh is usually highly fevered, foul-smelling or otherwise repulsive.

The last group which calls for consideration comprises the *parasitic diseases.* Animal parasites are organisms which are incapable of leading an independent existence, but which live and derive their nutriment from other animals, termed hosts. Five classes exist, of which the nematodes, or round worms, and the cestodes, or flat worms, are probably the most important. Trematodes, or flukes, external parasites and other parasitic states are not of very great consequence from the nutritional point of view. Parasites often cause extreme irritation to the animals affected, destroy the organs inhabited and generally render the flesh unfit for food. Few, however, are transmissible to man, it being usually sufficient to destroy the affected portion or organ, unless the meat is tainted or unless excessive emaciation is present, when the entire carcass and organs must be condemned. Of the nematodes only *Trichina spiralis*, responsible for trichinosis in man, is important. Although the parasite can be destroyed by thorough cooking, the carcass and all the organs should always be condemned. The cestodes are not of serious importance with the exception of *Cysticercus bovis* and *Cysticercus cellulosæ*, which produce tapeworm in man. When either of the two cestodes is present, it is usual to condemn the entire animal. Trematodes, whose common representative is *Distoma hepaticum*, or liver fluke, are unimportant, it being usually sufficient to condemn the animal's liver unless pallor and emaciation are present. Some external parasites, such as *bots, maggots and warbles*, may cause local irritation. Trimming of the affected portion will usually be sufficient. In the case of *acaridæ*, or scab, which is a notifiable disease, the whole carcass is condemned. Certain other parasitic diseases, such as those due to coccidiosis and sarcosporida, are of little importance, but *red water*, which only affects cattle, is a different category. Here the whole carcass must be destroyed.

Cooling

When meat is allowed to cool it loses a certain percentage of its weight owing to evaporation. The longer the process is carried on the greater will be the shrinkage. It is essential that the carcass should be cooled as quickly as possible after it has been dressed. The general practice in this country appears to favour slow cooling by hanging in a cool room adjacent to the slaughter-house, the carcass being hung for this purpose as soon as dressing and inspection have been completed. When the carcass has cooled sufficiently, it is split, quartered and stored in a cold room at temperatures in the neighbourhood of 29·4° F. Some authorities hold that slow cooling is necessary in order that the animal heat may escape and spoilage be prevented. Scientific investigation has proved, however, that quick cooling is as important for meat as it is for many other food products which contain heat of any type. This is particularly important if changes due to the action of bacteria and enzymes are to be inhibited. For this reason it is the practice in many meat-producing countries to chill the meat immediately after slaughter and inspection to temperatures in the region or 34° F. to 40° F. The size of the pieces into which the meat has been cut, together with the temperatures employed, decide the time to be occupied by the cooling process.

Meat, after chilling, should be removed to a storage room having a temperature below freezing point. This temperature and the humidity of the room is of prime importance in determining the final condition of the meat. Low humidity will to some extent dry the external surfaces of the carcasses and prevent the development of bacteria and moulds. An excessively dry atmosphere is not, however, desirable since meat stored under such conditions is apt to show excessive shrinkage. On the other hand, highly humid conditions favour rapid bacterial development and the growth of moulds. The colour of the tissues is also affected, while taints or offensive odours may develop. Temperatures at or near freezing point check bacterial growth and prevent these micro-organisms penetrating more deeply into the tissues. Meat can be chilled satisfactorily within twenty-four hours from the time of slaughter. Chilling cannot continue indefinitely without the production of substances which will eventually render the meat unfit for consumption. Certain enzymes present in meat cause autolysis, the enzymes elaborated both by bacteria and moulds eventually hydrolysing the tissue protein into chemical compounds. Generally speaking, the life of chilled meat depends to a considerable extent upon its fat. This may be attacked by fat-splitting enzymes which cause it to separate into glycerol and fatty acids. Hard white fat is more resistant to this action than is the yellow oily variety. Although these chemical changes, if allowed to continue for a short period, may cause the meat to become tender, their continued action will result in putrefaction and decomposition.

Those organisms or moulds which occur in meat free from any form of disease are not, with certain exceptions, likely to be dangerous to health. The suppression of their activities is, however, important, since they spoil the appearance of the meat and finally result in putrefaction. Moulds are usually more prevalent under refrigerated conditions than at normal temperatures, due to the absence of bacteria which inhibit mould growth. Torulæ and yeasts are also found occasionally on meat during refrigeration. Moulds, being aerobic, are normally present on the surfaces of meat and do not penetrate very deeply into the tissues. Some moulds produce pigments which discolour the meat. White moulds, which are extremely common, can usually be wiped from the surface of meat by means of a clean damp cloth. Black moulds, which cause a discoloration known as " black spot," may in some cases penetrate into the tissues and, if numerous, may render the carcass unsaleable due to putrefaction. If mould growth is not extensive, the affected portions only are removed. Blue moulds, which can develop at temperatures above freezing point, are more often associated with putrefaction than are other types. Mould infection of meat is chiefly caused by contamination during handling. It can also result from contact with the atmosphere, which may contain mould spores. All walls, floors, benches and ceilings of rooms in which meat is placed or in which it is stored should be frequently cleansed. The use of sodium hypochlorite solutions for cleansing purposes will discourage mould development. In this connection, the cleanliness and sweet condition of cold rooms represents an important point which is not always fully appreciated.

As the use of chemicals for the preservation of meat is prohibited, refrigeration accompanied by adequate cleanliness is the most suitable means of protecting meat from the action of bacteria. If this foodstuff is handled with care and is refrigerated in a proper manner, the use of chemicals should not be necessary. Souring of meat has occurred through lack of sufficient care in cleanliness, and is often due to the action of an aerobic organism known as *Bacillus megatherium*. Bone taint is another condition likely to be experienced. This is due to the retention of the body heat owing to inadequate cooling and to the action of an anaerobic organism, *Bacillus putrefaciens*, which causes putrefaction in the deep tissues situated along the bone. This fault is usually discovered after the carcass has been thawed out and may often be discerned by inserting a skewer along the bone. When this is withdrawn, the characteristic smell will be observed. Kidneys are sometimes greenish in colour due to retention of the body heat in the fatty capsule. Such organs should be destroyed as unfit for human consumption. Several species of anaerobic organisms have been discovered in sour or putrid meat. To prevent their development, quick cooling is necessary.

Large quantities of chilled and frozen meat are imported annually into this country. Chilled meat is often subjected to gas storage in the cold store, air containing from 10 to 20 per cent. of carbon dioxide being used to prevent mould formation or bacterial spoilage. Boneless beef which has been quartered, rolled and frozen hard has also been imported. It is usually sufficient to inspect 10 per cent. of the imported consignments. Generally, imported meat and offals exhibit a paler appearance than do meat and organs which have not been subjected to cold storage. A buff or greenish black stain is often present, due to staining of the tissues with brine. In some instances imported meat may smell strongly of ammonia, due to an escape of gas from the ammonia plant.

Meat which has been subjected to low storage temperatures should primarily be defrosted by thawing at chilling temperatures in conjunction with a plentiful circulation of air. If meat is defrosted too rapidly many of the nutrient juices will be lost by melting, as they are discharged from the tissues. Frozen meat will spoil much more rapidly than will the chilled variety. It is important, therefore, that defrosting should be gradual. The practice of rapidly thawing out frozen meat by means of artificial heat is to be deprecated.

Food Nutritive Values

Meat varies in composition according to type and condition. The moisture content of meat when fresh varies between 60 and 70 per cent. of the whole, while it contains approximately 20 per cent. of protein and averages 1 per cent. of mineral matter. The fat content is the most variable feature, being from 10 to 20 per cent. of the whole in the case of beef. Veal possesses the least amount of fat, while the fat content of mutton and pork may be anything up to 30 per cent. of the substance. As already mentioned, the population of this country formerly consumed much more meat than is the case at present. In addition, considerably greater use was made of the blood, offal, bones and marrow. Although the value of meat as a food is at present greatly limited by differences in methods of treatment in the home and by current shortages, it is still a most important food.

Meat is an excellent source of protein, a sufficiency of which is essential to provide an adequate diet. A more limited amount of animal fat is also available, together with some glycogen. The protein consists of amino acids, necessary for the development of the muscular tissues of the body. The protein of meat is equivalent in food value to that present in fish and eggs and is equally as digestible. It also supplies a suitable supplement to those proteins found in bread. Meat is a source of vitamins which are available in satisfactory quantities. Vitamin A is present in lamb, mutton, kidneys and in the livers of calves and pigs ; vitamin B_1 is found in fairly generous amounts in lean pork. Smaller amounts of this vitamin are present in lean beef, in hearts, kidneys and in beef liver. Substantial quantities of vitamin G are present in fresh beef and in pork liver. This vitamin is also present in fair quantities in veal, lean beef, pork, lamb and in the kidneys and livers of pigs and cattle. Liver is a potent source of vitamin C ; vitamin D is also present in the carcass fat. The glandular organs contain satisfactory quantities of vitamins A, B_1 and G, and smaller amounts of vitamin C. The vitamins present in the muscular tissue are not especially plentiful except in the case of vitamin G. Vitamins are destroyed to some extent during cooking operations, the vitamin C content being almost totally destroyed.

When meat is prepared for consumption, losses occur. These are due to shrinkage of the tissue caused by heat and drainage of the soluble matter into the fat or water in which the meat has been cooked. A substantial proportion of the fat is also wasted owing to liquefaction and drainage in the presence of heat. When meat is roasted, it should be subjected to initially high temperatures in order to seal the outside surfaces. In this way valuable juices in the form of soluble salts may be retained. Vitamins A or B_1 are not seriously affected by cooking, although excessively high temperatures may cause some destruction of vitamin B_1. Slow cooking, e.g. roasting or stewing, is particularly destructive to the vitamin C content. This destruction can be prevented, or at least minimised, by the use of cooking salt during the process. Frying also exerts a destructive effect upon vitamin C, probably owing to the high temperatures attained.

Epidemiology

Many diseases which affect animals slaughtered for food may be transmitted to man by means of the infected flesh. It must also be remembered that cooking is not likely to destroy any of the disease-producing properties of infected meat unless it is certain that every portion of the meat is properly cooked. Heat penetrates meat at an extremely slow rate, an allowance of thirty minutes being made for cooking each pound of meat. Experiment has proved that boiling is the most effective process as regards heat penetrability, roasting taking a secondary place.

Cattle, sheep and pigs suffer extensively from salmonella infections, S. *enteritidis* being the most common organisms responsible, although S. *aertrycke* has been discovered on a number of occasions. Salmonella infection may be acute, indeed fatal, yet the carcass may show no evidence of any changes and appear normal. Many epidemics have been traced to the consumption of unwholesome meat, German statistics being particularly informative in this respect. Ostertag reports 90 outbreaks covering 4,000 cases occurring within a period of 23 years. In discussing food poisoning outbreaks in this country, Savage and White have reported that approximately 50 per cent. of these were caused by meat or one of its many products. Many outbreaks due to the consumption of unsound meat have also been reported from America.

A severe outbreak of salmonella poisoning occurred during 1919 in South Africa, over 2,000 persons being affected. Mutton obtained from a sheep suffering from gastro-enteritis was proved responsible for the infection. On inspection no obvious symptons had been noticed. The carcass was released for sale, and from both the meat and the stools of the infected persons S. *aertrycke* was isolated. An outbreak was reported from Lancashire during 1935 in which beef from an animal affected with septicæmia was implicated. There were 174 cases, with 8 deaths. The carcass did not appear to be unhealthy but from all portions S. *typhi-murium* was isolated. In many cases the meat responsible for food-poisoning outbreaks had been consumed in the form of pressed beef. An extensive outbreak due to infection by S. *typhi-murium* has been described by Savage, 270 cases being affected. There were no deaths. The vehicles of infection were sausages and chopped meat, the causative organism being isolated from the meat and from the stools of the affected persons. It is believed that the meat was obtained from an animal which had been compulsorily slaughtered. It has also been reported that salmonella organisms have been found in the spleens and mesenteric glands of some 5 per cent. of all pigs slaughtered in this country.

Generally speaking, most meat-borne outbreaks are due to the ingestion of meat from ailing animals which have been slaughtered in an emergency in the hope that some portion of the carcass might prove, on inspection, to be saleable. Many instances have been reported during the last few years of the illicit slaughtering of animals due to the prevalent shortage of meat. Even where control of slaughtering is in existence, any inadequacy in this control may result in infection being transferred from the diseased to the healthy carcasses, particularly when an emergency slaughter takes place in the same room as that in which healthy animals are being dressed. Carelessness in the handling of diseased meat may also assist in passing on the infection, while the unsatisfactory dressing of a carcass in which diseased conditions are present may cause some of the contents of the intestines or stomach to be smeared over the other edible portions of the carcass. It should be remembered that many organisms which may be distributed in this manner are capable of causing illness and that they multiply rapidly, even at low temperatures. The consumption of improperly-cooked meat of this description may cause infection either directly from the diseased material or from any heat-resistant toxins which may develop. The flesh of animals suffering from septic or pyæmic conditions is capable of causing food poisoning, while reports received from Germany have indicated that the meat of calves affected with septic umbilical conditions, and also that from cows subject to inflammatory conditions following parturition, have been the cause of many illnesses.

Adequate cooking will destroy most pathogenic organisms. As already mentioned, however, this is not certain, whilst in this country the prevalent practice of eating under-cooked meat presents an additional danger. It should also be noted that, while the meat of the carcass may be harmless, the organs can be very highly infected due to a concentration of toxic substances within their structure. An outbreak of food poisoning due to mutton stew occurred in Edinburgh in 1926, a small number of persons being affected. Although no salmonella organisms were isolated from the remains of the stew, they were found in that part of the mutton which had not been used. The strain was proved to be pathogenic to guinea-pigs. Ostertag reports the case of a family which developed the signs and symptoms of food poisoning after consuming meat from a cow which was slaughtered owing to an injury to the udder, which later became gangrenous. In another outbreak, reported from Germany, forty-six persons were affected, one of whom died. The individuals affected had eaten meat from a cow which became ill after parturition. Innumerable instances have been reported of severe meat poisoning due to flesh infected with *S. enteritidis* and *S. aertrycke*. In many such instances a toxin had been produced which was not destroyed by cooking.

Staphylococcus aureus in cattle is associated with infections similar to those which affect human beings. Although definite evidence of human illness due to the consumption of infected meat is lacking, it is believed that these organisms may have been responsible for more outbreaks than have so far been reported. White has reported an outbreak involving five persons in Ipswich due to the infection of pressed beef with this organism. In 1948, an outbreak of food poisoning, also reported by White, due to canned brisket beef was reported. The causative organism was *Staphylococcus pyogenes* and twelve persons were affected. Very few outbreaks due to the toxins produced by *Clostridium botulinum* have been reported. Most of those which have come to light were caused by meat products which were insufficiently cooked. An interesting outbreak of acute diarrhœa due to cooked beef and involving thirty persons has been reported by White, onset occurring between four and fourteen hours after consumption. Bacteriological examination gave no indication of the presence of pathogenic organisms but a profuse growth of coliform organisms was found in a cleft in the substance. The beef had been cooked and remained in the larder until mid-day the following day. This attack emphasises the danger of storing prepared foods at room temperature overnight.

Horseflesh

It is not an offence to sell horseflesh in this country, always provided that it is properly labelled. Whilst there has been an increased sale of this type of meat during the last few years, ostensibly for the feeding of cats and other domestic animals, it is quite probable that the consumption of horseflesh by human beings has considerably increased. Sound horseflesh can do little harm, although it must be remembered that the slaughter of horses for human food may be carried out in entirely unsuitable premises, without adequate supervision or inspection. The value of horseflesh has increased so rapidly that it is now worth as much as that of normal domestic food animals. Horseflesh is dark red in colour, of coarse texture and possesses a yellowish fat. The odour is unpleasant. The whole substance is greasy, emitting a sickly odour, while the flesh never sets. A glycogen test is employed to differentiate horseflesh from other types of meat. This test must be carried out within a reasonable time after slaughter. Horseflesh for human consumption should be viewed with suspicion and inquiries instituted as to the place of slaughter and the methods of inspection.

Knackers' Yards

Closely allied to the problem of horseflesh is the knacker's yard, where horses may be killed for subsequent sale together with other ailing or diseased animals of all types. Infectious conditions present in the unfit animals may be transferred to the sound horseflesh, while conditions existing in many of these premises leave much to be desired. Much meat slaughtered under these conditions is sold freely to the public, both in its raw state or in prepared form. Greater powers of control and inspection of these premises is thus an urgent necessity.

Whalemeat

Up to the termination of hostilities the consumption of whalemeat was entirely unknown in this country. A desire to cater for the meat-eating public, backed by official circles, has caused this substance to be imported for sale. In spite of the liking for meat evidenced by a majority of our population, together with the efforts of many of our larger catering establishments, whalemeat has not become a popular article of diet. Some portions of the whale from which meat is obtained possess an extremely fishy taste which can only be removed by suitable methods of preparation. In a healthy condition, whalemeat is quite wholesome. Cases of parasitic infestation have, however, been reported, and careful inspection is necessary in every case. Regulations are now in force which provide for adequate inspection of whalemeat either on the factory ship or in the shore depot, qualified personnel having been appointed for the purpose. The method of inspection is based upon the principles laid down for meat in Memo. 62 (Foods), the flesh being classified according to its future use either as butcher's or manufacturing meat. The inflation of whale carcasses, the conditions under which the animals are killed, the system of handling, the cleansing and sterilisation of utensils and the cleanliness of personnel concerned in production of the meat are also regulated.

Control Measures

The detection of diseased conditions in meat seldom presents any great difficulty. Once disease has been detected the disposal of the affected meat is usually a matter of routine. The extent to which an infection has developed in the glands of an animal may not be so very obvious. As the glands are usually the primary seat of infection, some attempt should be made to gauge the extent to which infection has developed. It is not always easy to determine the commencement of decomposition in meat. Many experiments have been carried out to discover how this may be done. When decomposition has reached an advanced stage, no great difficulty should be experienced. In these circumstances laboratory tests would serve little useful purpose. Difficulty most often arises in the ascertainment of borderline cases. Incipient changes may not be evident even to the skilled inspector, who may feel that some form of laboratory test is required to confirm his diagnosis. This point possesses additional importance in the case of meat which is to be used for manufacturing purposes, since incipient decomposition may spoil much of the food produced. Numerous tests have been employed for this purpose. Counts of the anaerobic spores present, the reduction of methylene-blue, total bacterial counts, a calculation of the amino-acid content, the ammonia percentage or other forms of nitrogenous decomposition and the measurement of acidity have all been employed at various times and laboratory research workers continue to provide new tests which may be used for this purpose. An increase in the conductivity will provide a measure of the inorganic changes which have occurred, while organic changes, which are indicated by the freezing-point depression together with an increase in the volatile acid content, show that tissue breakdown has commenced. The best single test has not yet been chosen, so that most investigators rely upon the combination of a number of tests.

Meat placed on sale may have been obtained from diseased animals or may be subject to some form of bacterial spoilage or decomposition. Continued control is therefore essential after production. Preservatives may have been added to minced meat, a fact which is often indicated by its bright red colour ; while moulds, bacteria, parasites or insect larvæ may be present. Even when this occurs the meat may still retain its normal fresh appearance. Careful examination is thus of paramount importance. Dressed meat obtained from animals infected by disease may often be detected by the untrimmed portions of diseased glands which have been left adhering to the carcass, or by the absence of pleural or peritoneal tissues. Such evidence will necessitate a more detailed examination. Taints may readily be detected by inserting a clean skewer deeply into the meat, particularly along the bones. When decomposition is present, the characteristic odour will be evident.

The meat inspection service is mainly carried out in this country by lay inspectors, although in some areas veterinary surgeons assisted by lay officials are responsible for duties falling into this category. When this latter method is practised, the lay officials carry out the routine work, specialised problems being dealt with by the veterinarian. The veterinary profession continues to maintain that it should supervise the slaughter and inspection of all food animals. Up to the present there has been little evidence to show that such procedure would enable the work to be carried out more efficiently than is the case at present. It should be noted, however, that inspection may not be adequate in every case, this being particularly so in many rural areas. It is often stated that the cost of inspection is out of all proportion to the benefits obtained and that any protection to public health which accrues is very small, having regard to the cost of the service. In this connection, critics of the present system should bear in mind that it is quite impossible to assess the good which can accrue from the application of proper control measures. When obvious diseased conditions can readily be detected, much of the work of the expert lies in the determination of those border-line conditions which may, given the opportunity, adversely affect the health of the consumer. For this reason, the cost of such control measures represents an excellent insurance premium.

CHAPTER VI

MEAT PRODUCTS

THE most fertile sources of human infection due to the consumption of meat are those products which are prepared from meat and sold to the public in either a cooked or uncooked condition. It can indeed be stated that the majority of recognised infections attributable to meat are due to the consumption of these made-up foods, of which meat forms a major constituent. The methods employed in the preparation of many meat products and the conditions which exist in many of the smaller manufacturing premises leave much to be desired. It must be admitted that certain legal powers exist in the Food and Drugs Act, 1938, and that these powers can be of assistance in dealing with the conditions under which food is prepared and sold. Existing legislation has, however, been drafted in an extremely loose and vague manner, allowing the food manufacturer too much latitude. The current shortage of carcass meat and the small quantity now available for manufacturing purposes has also exerted a considerable effect upon the quality of the finished article. A greater quantity of filling materials are now being used to obtain the desired bulk, so that many more customers can be satisfied. Not all of this material may be suitable for food preparation purposes. Meat whose soundness verges on the border-line may also be utilised. The control of the ingredients employed therefore assumes particular importance.

It must be admitted that the inspection of the materials available and also of the premises in which meat products are prepared is not always carried out in a satisfactory manner. Several obvious reasons exist for this. Difficulties of inspection constantly arise through the lack of adequately trained staffs. The large number of small premises where such goods are prepared, all operating at varying times, represents another difficulty. The larger producers make adequate efforts to manufacture their meat products in a hygienic manner, both materials and methods being subjected to strict bacteriological and chemical control. As in the case of most food producers, the small trader cannot hope to cope with many of the most desirable modern requirements. This being the case, special attention must be paid to this type of premises. Apart from the condition of the premises in which meat products are manufactured, personal hygiene on the part of those engaged in the work is of particular importance. The quality of the meat, together with any other constituents used in the preparation of the finished article, must not be overlooked. At no time should any sub-standard ingredient, which might be contaminated or in the first unnoticed stages of decomposition, be used for manufacture. Particular care should be exercised to ensure that the food is not prepared, stored or handled in such a way as to permit any form of contamination.

Cooked Meats

Innumerable varieties of cooked meats are placed on sale in this country, especially in the industrial areas, where the allocation of manufacturing meat is somewhat higher owing to the greater working population of both sexes, necessitating ready-made meals being available. Meat and pork pies, brawn, rissoles, faggots, galantines and, to a lesser degree, hams and pressed beef are examples of the cooked foods which find a ready sale. *Pies* are made from cooked lean meat, the liquid from which is poured over the meat through the crust after baking to form a light-coloured jelly. *Brawn* is produced from meat cut from the heads of pigs and cattle. The jelly which becomes available when the meat is boiled is poured into a separate container the boiled meat being cut into squares, either with a knife or by means of a cutting machine. The meat is placed in suitable moulds, which are then filled with the liquefied jelly. The whole is then allowed to cool and solidify. *Galantines*, which should have a minimum meat content of 30 per cent., are made from veal, pigs' tongues and other meat to which rusk and seasoning have been added. *Potted meat* is prepared from lean beef, in moulds, the surface being covered with a layer of fat. *Faggots* or savoury ducks are made from scraps of liver, cooked sausage meat and other meat scraps, onions, bread or rusks, and are highly seasoned. The ingredients are minced and rolled into balls, which are packed in tins and baked for approximately two hours. *Meat pastes* are made from finely-cut cooked meat, from which all bone and gristle have been removed. This material is minced, rusk and seasoning being added. Mincing is continued until the resultant substance spreads easily. It is then packed into shallow dishes and coated with margarine or clarified fat to exclude air. It is also packed into sealed glass jars or cans. The meat content must not be less than 55 per cent. *Ox tongues* are a popular delicacy. The tongues are pickled for six to eight days, spice being sometimes added to the brine. It is usual to pump brine into the thickened portion of the tongue. Approximately one day's treatment is required for each pound of meat. The tongues are then washed and cooked for three to four hours, after which bones, outer membranes and surplus fat are removed. They are then packed into cylindrical containers and pressed, gelatine being added to fill in the interstices. Tongues are sometimes glazed externally, in addition. *Pressed beef* is usually prepared from brisket of beef, bones and surplus fat being removed before the meat is placed in brine. The meat is simmered for three hours and is then pressed. Glaze is sometimes applied.

Savage and Bruce White (1925), having studied 100 outbreaks of food poisoning, stated four important principles which emphasised the need for the special control of meat products. They pointed out that, as pieces of meat form the main constituent of prepared foods, there is little chance of tracing the animal from which this ingredient has been derived. As the organs were never available for inspection, the difficulties of proper supervision were increased. In addition, most of these foods have been subjected to a great deal of manipulation during manufacture. For this reason, if great care is not exercised, the risk of bacterial contamination is likely to be increased. They also drew attention to the fact that these foods have usually been heated and afterwards subjected to a process of slow cooling, and that this procedure assists bacterial development in a suitable medium. Their final point stressed the fact that the manufacture of these various articles is often carried out in premises adjacent to those in which meat is slaughtered, and that infection by pathogenic organisms may thus be facilitated. The Annual Reports of the Chief Medical Officer of the Ministry of Health almost invariably contain some mention of a disease outbreak which has been proved to be due to the consumption of infected cooked meat. An infected carcass obtaining entrance to a factory and being used for the manufacture of prepared foods which are distributed over a wide area might cause a serious outbreak of food poisoning, as proved to be the case in the west of England during 1937. This outbreak, due to an infected pig's carcass, caused 148 cases of severe gastro-enteritis with four deaths. The infecting organism was S. *enteritidis*. All the cases were traced to the consumption of one of the products of a single factory. An outbreak involving fifty persons occurred in Exeter during 1938. This was traced to brawn which had been prepared on the same premises in which calves which were recovering from an attack of calf dysentery were housed. The causative organism was S. *newport*, isolated from the brawn and also from the calves. Outbreaks of staphylococcal food poisoning have been traced to the consumption of infected meat foods. A small outbreak occurred in Dorchester during 1943, due to the consumption of infected meat pies, three persons being affected. *Staphylococcus aureus* was reported to be the causative organism. At the premises where the pies were made two persons were discovered with a staphylococcal infection of the nasal passages. An outbreak of a similar type occurred at Abingdon in 1943, due to brawn, six persons being affected. An outbreak at Barnstaple in the same year affected ten persons, and this also followed the consumption of infected brawn. The manufacturing personnel had apparently infected the brawn in each case. Meat paste has also been implicated in food-poisoning cases, whilst ham infected by the person responsible for carving it caused an outbreak affecting forty persons in 1943. Infections of this type are often due to butchers or workers with cut fingers or boils on the hands or arms. Botulism has also been produced by infected meat foods, an instance of this being a case reported during 1935 in North London, where *Cl. botulinum*, Type B, was isolated from a steak pie.

The *premises* in which cooked meats of any type are prepared are required to be registered under the Food and Drugs Act, 1938. The same Act deals with the precautions which should be taken in order to prevent contamination of the manufactured article. Close supervision of this type of premises is important. The cleanliness of production rooms, plant and utensils should be closely regulated. Many manufacturing premises are most unsatisfactory, being little more than outhouses situated at the rear of the shop premises. Since they have often been adapted for this purpose, the internal arrangements may be very bad, all the processes being carried out in one room. Every room should be well lighted and ventilated and have sound impervious floors and walls. Suitable lavatory accommodation, together with cloakrooms fitted with wash-hand basins provided with soap and towels and a plentiful supply of hot and cold water, should be considered essential. Processes which involve the use of heat should be carried out in a separate room. If this is not done, the development of putrefactive changes in the uncooked meat or in the final product is facilitated. All apparatus should be kept scrupulously clean, while cleaning and sterilisation immediately after use is most important. The tops of food-preparing tables should be covered with some hard impervious material, such as stainless steel, to afford easy cleansing. Food materials in uncovered receptacles should never be placed on or near the floor as contamination is likely to result.

The *food handlers* should be encouraged to practise the utmost cleanliness in their habits. Any persons capable of transmitting infection should be prevented from handling either the raw materials, the prepared food or the utensils which come into contact therewith. For this reason frequent medical and laboratory examinations of the personnel should be arranged. It has been often stated that the expense involved does not justify this procedure. It is probable, however, that some type of examination within the orbit of the National Health Service could be arranged with advantage. Not only should the employees be healthy ; they should keep their hands in a perfectly clean condition and should wear clean white overalls and head coverings when at work. The ingredients used for manufacture should also be closely controlled. In outbreaks of food poisoning in which meat is the basic content of the food involved very great difficulty exists in discovering the original source of infection. It is important, therefore, that some type of record should be maintained which will allow this to be done. The wrapping and distribution of many prepared meat foods could be greatly improved and would assist considerably in obviating danger likely to affect the consumer. This is particularly the case with food sold in an imperfectly cooked condition. Instances have been reported in which unsound canned food has been used in the preparation of various cooked-meat products. Constant inspection of the materials used is therefore necessary.

The *methods* practised in retail premises also leave much to be desired. There is, for instance, no legislation at present in existence which will prevent a customer from handling foods of this type when exposed for sale. Fortunately, this practice has to a large extent ceased, due to improved educational standards. Shop assistants are not entirely free from blame. Serving methods in the bigger food stores are usually satisfactory, but quite frequently the assistant will cut slices of cooked meat and lift them on to the scales by hand. Other prepared meat foods are similarly treated. This practice should be abolished. Proper measures of hygienic handling and personal hygiene should be encouraged, together with the frequent use of hand-washing facilities. Such facilities should always be readily available.

Inspection of cooked meats is, of course, essential, signs of decomposition being sought on such occasions. In dealing with cooked hams a skewer should be inserted along the bone or into the thicker portions of the flesh. When withdrawn, an offensive odour will be quickly noticeable if any decomposition is present. The age of a meat pie can usually be judged from its pastry. Decomposition in its contents can be also detected by means of a skewer inserted through the vent in its upper crust. Wrapped pies may become mouldy or sour. This is almost invariably due to packing whilst in a warm condition. Decomposition in brawn, potted meat, galantines and similar products is demonstrated by the growth of moulds and by the liquefaction of any jelly which may be present.

Sausages

Of all the meat products placed upon the market in prepared form, sausages are the most popular. The pre-war sausage contained a high percentage of meat and was extremely appetising and nutritious. The present-day article is a poor substitute, although more meat is now permitted in its manufacture. Sausages are, however, in short supply at the present time due to the scarcity of manufacturing meat of a suitable type for their production, and the supply by no means equals the demand. The term " sausage " is applied to a number of meat products which are prepared from minced or chopped beef or pork to which are added cereal fillers such as bread or rusk, together with condiments and flavouring materials. The resulting mixture is forced into skins or casings of various shapes and sizes, some of which may be synthetically manufactured.

Usually only raw beef or pork is used for the manufacture of *uncooked sausage*, sound edible meat of poor quality being generally employed for this purpose. Beef sausages must have a minimum meat content of 50 per cent., but in the case of the pork variety, 65 per cent. must consist of such meat. In this way a good outlet for this type of meat is provided, as there would be little demand for an article of this quality under normal circumstances. Whilst sound meat is generally used for this purpose, it should be borne in mind that opportunity is afforded for the use of unsuitable materials in manufacture which is available in few other foods. Stale meat pies, galantines and brawn have, on occasion, been used. Meat from bull carcasses is often employed in sausage manufacture, as this type of flesh is able to absorb water to a great extent, while it is firm and possesses little fat. Present-day sausages contain a high percentage of cereal fillers such as bread, rusk, oat groats, rice, soya flour, cornflour, chopped bread, while even skimmed-milk powder is the latest recommended addition. These fillers provide binding power and hold moisture, their employment providing the desired plumpness and juiciness in the finished article. The condiments used are normally salt and pepper, but saltpetre or sugar may be incorporated in the mixture. In some instances a variety of spices or herbs also form part of the contents. Tastes in seasoning appear to vary from district to district.

The sausage skins are generally derived from the cleansed intestines of cattle, sheep and pigs, although, as previously mentioned, artificial casings have been widely used for some types of sausage since 1939 but not for the fresh variety. The method of preparing animal casings is further discussed later in this chapter, in the section dealing with gut scraping (see p. 75). Owing to the shortage of sausage casings, sausage meat is also sold in a loose condition, being thus open to more contamination than would normally be the case. The various constituents are weighed, mixed and placed in a grinding or mincing machine. This process is continued until the desired consistency has been attained. The flavouring ingredients are then added and the whole thoroughly mixed. The process of mincing or chopping generates heat in the meat, the temperature rising as much as 15° F. This rise in temperature is very favourable for bacterial growth. The batch of material is then placed in the barrel of the sausage filler and is forced under pressure, by means of a plunger, into the skins or casings placed ready to receive it, after which the familiar links are produced by giving a twist to the tube at regular intervals. There are many types of sausage-filling machines on the market, but those of the vertical type which are provided with porcelain-lined barrels are to be preferred. This type allows the operative's hands to be free, prevents excessive handling of the meat and is easily cleansed. Large quantities of pork sausage meat in cans, which contains a high meat content, have been imported from abroad. If the addition of a preservative is desired, sulphur dioxide may be added, being used in the ratio of 450 parts per million. At present the use of preservatives has considerably declined, but if they are employed the sausages must be labelled to this effect. Other raw varieties are whalemeat sausages, which made their appearance after whalemeat began to be imported into this country, vegetarian sausages and sausages whose meat content is composed of horseflesh. In this latter case the contents must be specified.

Apart from the uncooked varieties of sausage, mention must be made of a number of *cooked varieties*. Many of these are cured by smoking, while others are cooked in water heated to 180° to 190° F. Saveloys, smoked sausages, polonies, breakfast or luncheon sausage and black or white puddings are all types of the prepared varieties which are sold ready for consumption. Many are dyed, being either dipped in the dying material after cooking or the substance may be added to the cooking water. *Saveloys*, whose main constituent is pork and which are frequently highly flavoured, are not often available for sale owing to shortage of the necessary raw meat constituent, although beef saveloys have been manufactured to some extent. *Polonies*, noticeable on account of their red skins, are normally manufactured from cooked pork trimmings, to which are added flavouring materials and suitable fillers. The meat content should be 30 per cent. of the whole. *Luncheon or breakfast sausage* which should have a 30 per cent. meat content is made from coarsely ground beef or pork which has been cured by smoke for a short period before being stuffed into casings. *Liver sausage* is a very popular article, identifiable by its grey colour. As might be expected, liver is the main ingredient. This substance gives the product its characteristic flavour. It may, however, contain a moderate proportion of other types of meat provided the total amounts to 45 per cent. of the whole, together with filling materials used to eke out the other raw materials, and often employed to excess. Smoked liver sausages are also manufactured. *Black or white puddings* are often seen in industrial areas, the black variety being the most common type and finding a ready sale. The blood, which is obtained at the time of slaughter, is the main ingredient. This is then mixed thoroughly with groats, oatmeal, pieces of fat or suet and other seasoning materials and then filled into casings. The puddings are then cooked for forty minutes in water at 180° F., being afterwards dyed black and sometimes dipped into soda solution to impart a glossy surface and to intensify the black appearance. *Smoked sausages* are becoming very popular in many areas. These are prepared from beef or pork trimmings, and after the casings have been filled, they are smoked and cooked for a short period. " Smoke " powder may be mixed with the meat if desired. There are also a number of imported sausages, such as the Frankfurter and Bologna types, together with salami. These are chiefly favoured by our foreign population. Many are uncooked, the meat used in their constitution being dry cured and afterwards smoked. Preservatives may be added.

The *nutritive value* of sausages is mainly dependent upon their meat content. Under certain circumstances this may be very satisfactory. There are, however, a number of grades of sausages even of the same type. From a dietary point of view the value of these articles not only depends upon their contents but also upon their condition. Uncooked sausages readily decompose and become unsound ; the cooked varieties, while possessing a more lengthy life, will not keep indefinitely even when cured. Rapid decomposition can be delayed by the employment of good-quality, sound materials manufactured under hygienic conditions, and if the sausages are handled in an efficient manner until consumed their expectation of useful life will be increased. Sausages which are unsound are darker in colour than normal, while the skin is brittle and dry. When in this condition they can be broken easily into pieces, their contents being sour and showing evidence of mould growth. Cooked sausages in fresh condition should be dry when cold and should be firm and solid. If decomposition has begun, they will be soft, slimy and will rapidly become mouldy. To test for decomposition a portion should be cut lengthways and smelled. Alternatively, a small piece may be placed in a saucer and boiling water to which has been added a small quantity of lime-water poured over the sample. This will bring out the characteristic smell of decomposition. A sausage without the addition of preservatives generally smells most offensively before any moulds make their appearance, but if preservatives have been incorporated in the mixture the normal smell of decomposition will not be generally perceptible before the moulds appear.

Cases of food poisoning caused by the consumption of infected or unsound sausages have not occurred to any great extent in this country, since most of these articles are bought, cooked and eaten almost immediately. Contamination may occur, due to infection from the operative, dirty hands or clothing, soiled or improperly cleansed utensils, fouling of ingredients by rodents or other animals, exposure to flies or contamination in the shop premises when exposed for sale. Fatal cases have occurred, however, mostly in connection with the ready-cooked types. Botulism has also been contracted from this source. As some of the smoked types are uncooked, decomposition may be rapid. Smoking may also present difficulty in the case of sausages of large diameter. It has been reported that, if the casings are incompletely filled and some air is present, poisonous properties do not develop in every case, probably due to the inability of the type of anaerobe present to multiply. Care in handling all types of sausages, the use of sound ingredients and the proper cooking and storage of the varieties sold ready for eating represent the main preventive measures.

Fat Melting

Large quantities of animal fats are used annually for manufacture into margarine and for *dripping* and lard required for culinary purposes. The fat from the paunch, heart and pluck, together with the caul fat and other scraps and pieces trimmed from the carcass, are used for this purpose. The control of all animal fats of the edible variety is vested in the Ministry of Food, the disposal of fat being very strictly supervised. The clean fat, after slaughtering has been completed, is removed to a cutting machine, which slices or chops the larger portions so that they may be cooled quickly. These portions are often washed and chilled at temperatures below 40° F. and are then stored in a cooling vat. The water is finally drained from the fat, which is chopped into still smaller pieces. These are fed into steam-heated digesters, the fat being rendered liquid and drained off, while the residues are often utilised for animal feeding.

The digester is generally equipped with agitators, which keep the materials constantly in motion and allow frequent contact with the heated sides of the apparatus. Moisture is expelled from the fat during this process, the fumes being either expelled or drawn off by means of a vacuum and afterwards passed into the boiler flues or through some form of condenser. The residues are usually allowed a period of drainage in order to obtain the highest possible percentage of fat. In some instances they are pressed. Salt is sometimes mixed with the fat to ensure more complete separation. The liquid is often clarified by filtration and then run into containers lined with greaseproof paper or into tins or casks. In the case of all edible fats it is important that sound fat, free from all traces of decomposition, should be used for melting purposes. The packaging should be above suspicion. Rapid cooling after packing is essential in order to prevent the growth of moulds. Some years ago, when supplies permitted, many butchers rendered down their own fats into dripping or lard, and this procedure is now commencing again on a reduced scale. These materials have a ready sale. This practice is not without danger of contamination. Unhygienic conditions may cause danger to the consumer, particularly if the fat is consumed in its natural state on bread in the form of dripping toast, a meal which is greatly appreciated by many individuals. The rougher types of fat are employed in the manufacture of candles, tallow and grease. Apart from fats used for edible purposes, the good-quality fats are also manufactured into glycerine. As with all edible substances, suitable handling is again important. Dripping should contain not less than 99 per cent. saponifiable matter and not more than 1·5 per cent. free fatty acids.

Lard, which is very important from the culinary point of view, particularly in relation to the manufacture of pastries and other forms of confectionery, is produced from pork fat. On a commercial scale three methods of manufacture are employed. *Prime-steam lard* is produced in heavy steel rendering tanks which are insulated to prevent any possibility of heat losses. Each of these tanks is provided with an aperture through which the material is fed, a draw-off valve for removing the melted liquid and a gate-valve through which the residual matters may be withdrawn. Loading is important, the fat and other materials being placed in the tank as water is run in. Water is a valuable addition, as it prevents any possibility of the materials packing and assists in the quicker heating of the fat. When the tank is full, the water is heated by means of steam to boiling point and is later withdrawn from the tank, carrying with it the blood and other extraneous matters which may be present. A further supply of cold water is admitted to the tank and the steam again turned on. Air is expelled through a valve, the pressure is increased to approximately 40 lb. per square inch and the fat in the tank thoroughly cooked. The liquid lard is superimposed above the small amount of water, which contains the residues which have settled to the base of the tank. A small quantity of salt is usually added in order to assist in the more complete separation of the fat. The whole is allowed to stand for two hours or longer, after which the liquid lard is withdrawn. All moisture should be removed from the lard, as water contains a certain amount of nitrogenous matter which favours fermentation and souring. The lard may then be packed, although it is often still further refined in order to effect clarification, remove excess moisture and other impurities and to bleach it. The product is then run into a suitable tank in which it receives a further heating, and is agitated either mechanically or by means of compressed air. Mechanical agitation is the method most favoured, as with this system the materials mix better and rancidity does not develop. Bleaching and clarifying agents are employed. Fuller's earth is the most popular material used for this purpose, although carbon black and diatomaceous earths are also employed. The latter articles are excellent clarifiers but do not possess suitable bleaching properties. It is important that as little of any of these substances as possible be employed, otherwise the flavour and keeping quality may be harmed. After this treatment the lard is filtered until it is clear. It is then ready for packing when cool. Smooth lard is cooled rapidly to prevent the oil and stearin separating. After being pre-cooled to 110° F., its temperature is quickly lowered by refrigeration. Lard which has been rapidly cooled is able to withstand higher temperatures without melting.

Grainy lard is prepared during cooling, and as a result the solid portion possesses a grain-like appearance, while the liquid portion is not mixed but is allowed to separate out. The lard may be allowed to grain in the storage tank, after which it is packed ; or it may be poured whilst hot into its final containers, which may be pails, tubs, barrels or boxes. The external surfaces of all wooden containers should always be painted or varnished to prevent any possibility of dirt being ground into the material. The internal surfaces of such containers are sometimes treated with a sodium silicate solution to prevent absorption and waste, while paraffin may be similarly employed. The use of parchment or greaseproof paper is to be preferred to these methods for lining containers. It is important that these receptacles should be perfectly clean before they are filled. *Neutral lard* is prepared in a water-jacketed kettle. During the slow heating process the lard separates from the fibrous material. This type of lard is white but has little flavour and is often used in the manufacture of margarine. *Kettle-rendered lard* is produced in steam-jacketed kettles, the moisture being boiled out and the fat separated from the fibre. It is packed hot and is stated to possess the finest flavour of any of the types. The colour is darker than that of those types obtained by steam treatment, although the yield per hundredweight of fat is not so high.

Lard should be white, hard, firm, free from smell and should only contain the merest trace of moisture. Rancidity is quickly demonstrated by a sour taste and smell. Lard is often adulterated by means of cotton-seed oil or by the addition of moisture. To detect the addition of water the lard should be heated in a conical glass, when the water will sink, leaving the greasy portion to float to the top.

Tripe

The stomachs of food animals are almost invariably used for the manufacture of tripe, which finds a ready sale, particularly in the industrial areas of our northern counties. Large quantities are eaten in these areas along with cow-heels, trotters and pigs' feet, these latter articles being derived from the hoofs of cattle, sheep and pigs. These foods are frequently eaten after their initial boiling, but in the south of England they are generally cooked again before they are eaten. When eaten in a once-cooked condition, with the addition of pepper, salt and vinegar as is the common practice, danger may arise, particularly if the materials have been contaminated after production. Such contamination may occur in the retail shop, where the article is usually served or weighed by the bare hands of the assistant. The quantity available for sale has decreased owing to the reduction in the number of animals being slaughtered for food in this country.

When tripe is prepared, the contents of the various stomachs are emptied. They receive a rough wash before being hung up to drain. They require to be " dressed," and for this purpose are placed in hot water for fifteen minutes, after which they are again hung and the mucous surface removed with a sharp knife. By this means the brown epithelial tissue is stripped off, leaving a fresh white surface exposed. The tripes are then rinsed in water and are boiled in coppers for periods varying from two hours in summer to two and a half hours in winter. When the boiling process is complete, the peritoneal layer is stripped away, the tripes being soaked in cold water until ready for transport. They are usually packed in hampers for delivery. These containers should be kept scrupulously clean and should preferably be lined with greaseproof paper. Tripe dressers usually prepare ox feet (cow-heels) and the feet of sheep (trotters) in a similar fashion. Pigs' feet, when removed from the carcass, are sold either raw or in a boiled condition. The udders of cows are boiled and sold under the name of " elder."

Fresh tripe spoils very rapidly and in some cases may be slightly cured by salting or preserved by pickling. If sound, it should be firm, springy to the touch, cold and slightly moist. If wet and slimy and possessing a sour odour, it is unsound and should be condemned. Frozen tripe, which is imported in large quantities, quickly decomposes and may also be affected with mould growths.

Chitterlings

This meat product is closely allied to tripe and is prepared from the large and small intestines and the stomach of the pig. These organs are cleaned, turned inside out and washed, soaked for a period in salt water, plaited, seasoned and boiled for two to four hours. When inspected, it is important to examine them for evidence of excremental contamination, which denotes improper cleansing. Chitterlings spoil very rapidly. When sound they are whitish-grey or pink in colour, are firm to the touch and are slightly greasy. When stale they are wet and shiny and emit a very offensive odour.

Gelatine

Gelatine is a meat product and is widely used for a variety of purposes. It is a favourite base for desserts and jellies as it is able to incorporate within its mass many times its own weight of water, and can also absorb a variety of colours and flavours. It is widely used in the manufacture of ice-cream on a commercial scale, improving as it does the composition and texture of the frozen product. As a protective colloid and emulsifying agent, gelatine is valuable to the confectionery trade, where it is employed in the manufacture of artificial cream, sweets of various types, pastes and fondants. Gelatine is also employed for icing in the manufacture of meringues and for a variety of confectionery fillings. It has also been reported that gelatine may be a beneficial addition to the diet of infants. The pharmaceutical industry uses large quantities of this substance annually for covering various types of capsules. Gelatine is extensively manufactured in this country, although much low-grade material of doubtful metallic purity is imported annually from abroad.

As the raw materials used in the manufacture of gelatine are by-products of the slaughter-house, the gelatine industry is closely allied to the meat trade. The principal materials used are hide and skin trimmings, bones, horn pith and pig-skins. A bone material known as ossein, which has been treated with acid to remove the calcium and phosphate content, is also used for gelatine manufacture. In addition, large quantities of dried bones are imported for manufacturing purposes. The main purpose of the process is to extract the collagen by means of hot water from the raw materials at the requisite temperature and concentrate the extract by the removal of water. The raw materials are washed, cleaned, degreased and chemically treated. They are then cooked in water by means of steam coils. Cooking requires careful control, as the quality of the final product depends upon the extraction temperature. Several extractions are made, tests being carried out by means of a hydrometer until the desired concentration has been attained. When processing is complete the extract is drawn from the base of the cooker to eliminate any fat or oil. The hot extract is piped to storage tanks, from which it passes through filters of the plate or frame type, using kieselguhr or canvas as the filtering medium. Cellulose-pulp filters are also employed. The filtered extract may then be treated in one of two ways. It may be poured into rectangular metal pans which are immediately subjected to refrigeration, the sheets being removed, after cooling, for drying. Alternatively, it may be concentrated by evaporation, the concentrate being conveyed on rubber belts through a refrigerated tunnel. At the end of half an hour the gelatine emerges in the form of sheets. These sheets are then placed upon wire-mesh frames and passed through a drying tunnel, this process taking fifteen to thirty hours. The final product is either retailed in sheet form or is ground before sale. Gelatine should be stored in a perfectly dry atmosphere, as if it is allowed to become moist or liquefied, it forms an excellent culture medium for the growth of bacteria.

Edible gelatine should contain not less than 15 per cent. of nitrogen and not more than 3·25 per cent. of mineral matter. Preservatives in the form of one part of sulphur dioxide per 1,000 parts of gelatine may be added. Limits are also placed upon the amounts of arsenic, lead, copper and zinc which may be present. In each million parts by weight, it should contain not more than 1·4 parts by weight of arsenic, 10 parts by weight of lead, 30 parts by weight of copper or 100 parts by weight of zinc. The factors which govern the final quality of gelatine, as set out by Heyl, are :—

(*a*) The type of stock used in its manufacture.
(*b*) The chemical treatment of the stock.
(*c*) The heat-treatment of the stock.
(*d*) The pH of the stock.
(*e*) The moisture content of the gelatine.
(*f*) The quantity and types of metal salts which are present.
(*g*) The gel strength.

The manufacture of gelatine requires careful technical control. The hygienic supervision of production and distribution is also of the greatest importance. Bacterial growth will materially reduce the quality of gelatine and will cause spoilage. For this reason rapid chilling and drying are essential.

Glandular Products

The production of large numbers of medicinal preparations depends upon extracts from the glands of food animals. This aspect of meat by-product utilisation has assumed considerable importance during recent years. As the supply of glands derived from home-killed animals is now limited in quantity, large quantities are imported annually from abroad. The glands required for this purpose are skilfully removed from the carcasses after slaughter, freed from fat and tissue, and are subjected to further treatment with as little delay as possible, being either frozen to − 10° C. or placed in acetone. Examples of glandular products are insulin, thyroid extract, splenic extract and adrenalin. Liver extract is manufactured for medicinal purposes, rennet from the stomach of the calf and pepsin from the stomach of pigs. Glandular substances are also employed in the manufacture of synthetic enzymes, hormones and other pharmaceutical preparations.

Gut Scraping

The intestines of food animals represent very important by-products, particularly from the point of view of sausage manufacturers. The intestines of cattle are utilised as casings for black and white puddings and for saveloys. The fat is first cut away with a sharp knife, care being taken to ensure that the gut is not injured in any way. The guts are then turned inside out with the assistance of running water, the new external surface being scraped with the edge of a hard piece of wood. The casings are then salted and stored in barrels under pressure. The intestines of sheep and pigs are used for the smaller sausage casings. This is a much more offensive process, as the gut is often in a semi-putrefied condition before scraping is begun. When the intestines have been emptied of their contents, they are placed in water and allowed to remain until putrefaction is well advanced, when they are transferred to a fresh tub of water. They remain in this liquid for a further period, at the expiration of which they are removed and spread on a cleaning board, a piece of hard wood or a metal scraper being employed to remove the unwanted tissues. The guts are then pickled for several days. This process removes the offensive smell. They are then measured into bunches or bundles and stored in dry salt for a period, after which they are ready for use. As the casings are used for containing edible materials, their hygienic production and storage is important.

Other Products

Meat Extracts possess a ready sale under various proprietary trade names. They are generally prepared from lean beef, which is extracted by means of boiling water under high pressure. The resultant liquid is evaporated under vacuum. These extracts are in themselves usually by-products of the preparation of preserved or canned meat. The filtered liquid after concentration should preferably possess a moisture content of 18 per cent. Overheating in the final stages of processing may cause the destruction of the creatine which normally changes into creatinine. During storage a reversion to creatine may occur. This phase is most noticeable when the moisture content of the extract is higher than 20 per cent. In some instances the concentrated liquid is dehydrated and is sold in powder or block form, for the sake of convenience in packing and distribution.

The loin or kidney fat of the ox is sold as *suet*, either in its simple form or pre-packed as the shredded variety. After all traces of blood and glands have been removed, the suet is minced and dusted with rice flour, up to 8 per cent. of this substance being permitted. Suet contains a small percentage of moisture and approximately 1 per cent. of insoluble matter. Not less than 83 per cent. by weight of shredded suet should consist of fat. *Bones* are used for the extraction of glycerine, whilst the *blood* is frequently dried for manufacture into blood albumen after defibrination. This latter process is carried out by stirring with a clean sterile rod, after which the blood is treated with chemicals and finally dehydrated. A colourless powder is produced which is used by bakers in the place of egg albumen. *Soups* are prepared from the bones of the carcass and the tails of cattle, the extracted liquor being used for stock. Meat soups should not contain less than 6 per cent. by weight of meat, excluding bone and fat, while oxtail soup must contain not less than 2 per cent. by weight of whole oxtail including bone. The total meat content of the latter type, however, excluding bone and fat, should not be less than 6 per cent. by weight. Many varieties of soups are prepared and sold in cans, being ready to serve after dilution and the application of heat.

CHAPTER VII

MEAT PRESERVATION

The preservation of meat has been practised for centuries, many of the methods originally employed, such as drying, pickling, salting or smoking, being still in daily use. Even before the scientific principles of canning and refrigeration were elaborated meat had generally to be preserved for lengthy periods, particularly during the winter months. The absence of an adequate supply of feeding-stuffs for cattle rendered the slaughter of many animals in the autumn necessary, the meat being preserved for future use by salting or pickling. In dealing with carcass meat, none of the older methods can compare with *canning*, which enables the products to be preserved in good conditions for almost indefinite periods. As canning is dealt with in Chapter XXV, it will be sufficient to state here that beef, mutton and pork are canned both in this country and abroad, while large quantities of canned meat are imported annually from foreign meat-producing countries. Of the remaining methods employed *refrigeration* is the method most widely used.

Refrigeration

The refrigeration of meat is extremely useful inasmuch as the growth of bacteria is inhibited while the food remains in cold storage. It must always be remembered that refrigeration is not a method of sterilisation ; none of the pathogenic or non-pathogenic organisms which may have infected the meat prior to storage at low temperatures will be destroyed by its application. Indeed, some organisms may multiply slowly at temperatures in the neighbourhood of freezing point. Once meat is removed from the refrigerator or cold store, the temporary inactivity of the organisms will cease and they will begin to multiply rapidly in suitable temperatures. When meat thaws, a film of moisture is formed upon its external surfaces. This provides a suitable medium for bacterial development. In view of this the practice of periodic removal and return of meat from low-temperature storage into the shop where it is sold represents a dangerous practice. Fortunately, this procedure is by no means common.

The employment of refrigeration or other means of low-temperature storage for the preservation of meat is not a modern discovery, the advantage of this method having been recognised and practised for centuries. In olden times caves and holes in the ground, together with cool water from wells and springs, were widely used for preserving meat killed in the chase. These methods, primitive though they were, survived for many years. When the value of ice for cold storage purposes came to be fully realised, large quantities were transported for great distances to assist in the maintenance of meat in a sound, sweet condition. Modern methods of refrigeration have also been of great assistance from the nutritional point of view, as meat can now be stored in times of plenty. This was of great value during the war years. In addition, much valuable meat has been rendered available for daily use, as it can now be transported over long distances and stored almost indefinitely, in or out of season. Conversely, the requirements of the consuming public have assisted in no small degree in the development of mechanical refrigeration. In short, the meat industry owes much of its rapid growth to the discovery of refrigeration.

Refrigeration in relation to meat first developed in the form of cold stores situated at the ports of entry and in large towns. In the first instance these stores were employed for the storage of meat for short periods. Afterwards their use was extended to cover other imported foods, such as bacon, butter, cheese and other perishable articles. If this process had not developed as it has, the food situation in Britain would have suffered appreciably.

The importation of meat under refrigerated conditions, and more particularly its storage until required for use, has compelled the retail trader to provide some means of preserving his supplies until sold. Initially, ice-boxes were designed for this purpose, the various cold-storage companies carrying on an extensive trade in this commodity. Ice-boxes were also used to a lesser extent in domestic premises, although the consumer was really unable to enjoy the benefits of low-temperature storage until the modern type of automatic refrigerator was obtainable at a reasonable cost. The need for some form of cold storage, not only for meat but for other foodstuffs in the home, is now generally recognised, even for working-class communities. Many local authorities are installing refrigerators as standard fittings in their new houses.

As already mentioned, much more meat has been made available by the employment of refrigeration, which prevents decomposition or spoilage. Decomposition is due to two changes, one of these being the result of bacterial activity, and the other of autolysis. Low temperatures prevent these changes by decreasing the growth rate of any micro-organisms which may be present and by reducing the autolytic action due to enzymes normally present in the meat. If the bacterial content of any foodstuff is high, the changes due to their development under optimum conditions are likely to be more rapid. Their action will alter not only the quality and taste of the affected article but also, if carried to excess, will produce offensive odours and may, indeed, cause variations in chemical composition. Bacteria of different types require certain temperatures to assist multiplication. These temperatures vary from freezing point to the upper limits of the normal temperature scale according to the type of organism concerned. From the point of view of meat spoilage it is the middle temperature ranges, between 50° F. and 100° F., which are most important, as between these points lie the most suitable conditions for the growth of most pathogenic organisms.

Organisms require food in addition to suitable temperatures, while moisture is particularly important. Under normal conditions all meat contains a certain amount of moisture. Under cold-storage conditions this moisture is crystallised and is not available for bacterial growth to the same extent as would be the case at normal temperatures.

Apart from the economic advantages gained by the employment of refrigeration, public health considerations are significant. The refrigeration of meat, when properly applied, has enabled large and increasing quantities of meat to be supplied for human consumption, while the incidence and transmission of certain diseases, particularly food poisoning, has been considerably reduced. It must not be thought that the process is devoid of criticism. It has, for instance, been stated that the food value of the refrigerated product is reduced, that its taste and flavour is spoiled. There seems to be little or no foundation for such criticism.

Freezing temperatures applicable to Great Britain, together with the temperatures at which meat is chilled, have already been set out on p. 57. In other countries meat may be frozen at temperatures varying from 14° F. to 21° F. In considering the refrigeration of meat some knowledge of the structure of the muscle tissue is essential. This is composed of innumerable water-bearing fibres, each enclosed in a thin sheath. The connective tissue is made up of groups of these fibres together with blood-vessels and nerves. The structure outline is important when the method of freezing is taken into account. If meat is frozen slowly, the ice crystals are larger, and they are normally located outside the muscle fibres. When rapid freezing is practised, the crystals are smaller and are more widely distributed within the muscle tissue. It has been stated that smaller crystals imply better-quality meat, although this is open to doubt. The quantity of ice crystals formed depends upon the temperature employed.

When rigor mortis occurs in slaughtered animals, the semi-fluid contents of the muscle tissue stiffen. As already pointed out, this condition passes away after a period, the tissues returning to their original state. These changes are connected with the water content of the muscle tissue. It is stated that moisture passes from the tissues into the adjacent spaces during slow freezing, a process which is not likely to improve the quality of the meat. On the other hand, just as suitable rapid-freezing methods have an important bearing upon the quality of the meat, so the method of thawing is important. Rapid thawing is not advisable, as the water content which has been crystallised in freezing melts when the meat is thawed. This water, if allowed to drain from the meat owing to rapid thawing, will carry away certain nutritive properties. Slow thawing assists in the re-absorption of this moisture content into the tissues. It has been estimated that freezing should be completed within thirty minutes. Small portions only of meat should be frozen quickly. For a variety of reasons this is not always possible.

Far too many cold stores are maintained in an unhygienic condition. This is particularly the case with butchers' cold rooms, which are often wet and unsightly, with slippery, damp floors and with moisture condensing on the walls. Cold stores should preferably be cooled by means of a forced-air circulating system. Direct-expansion ammonia coils should be arranged with baffles in a coil chamber, which should be located outside the room. A motor-driven fan is necessary to drive the chilled air through the ducts. Once distributed, the air should be returned over the coils to the coil chamber. This method of delivering cold, dry air to every part of the store provides ready cooling and improves the keeping quality and final condition of the product, mould growth being inhibited by the dry atmosphere. The room will be clean, dry and sweet-smelling, with a complete absence of moisture. On a smaller scale, retail cold rooms require just as much care and attention. Far too many are found in a dirty condition, littered with partially-decomposed meat scraps and other refuse. The old-time ice-box should be prohibited owing to the difficulty of maintaining a constant temperature by its use. Too little care is at present exercised in the matter of refrigeration, which is often taken for granted. An all-round improvement would be beneficial to the owner no less than to his customers.

Drying

The drying of meat is an ancient art, being originally a method of preservation employed by aboriginal tribes and by the North American

Indians. The resultant product was given the name of "jerked beef." The meat was cut into strips and dried in the air, this method of treatment rendering it hard and tough. Before it was cooked the meat was softened by soaking in water. Dehydrated meat is the latest development of this ancient method, the final product being granular in appearance. Dehydrated meat has been used in this country for culinary purposes, chiefly in hotels and in restaurants. It is stated to be extremely nutritious. The general principles to be followed in connection with dehydration are discussed at greater length in Chapter XXIV.

Salting

The preservation of meat by means of salt is another method which dates back to ancient times. This process is employed both on a commercial scale and also by many inhabitants of our rural districts. The use of salt and other chemicals as preserving agents is of considerable value in country districts, where facilities for refrigeration are often scarce. In some cases salt only is employed, this material exerting a preserving action and improving the final flavour. High-grade salt is necessary as many of the commoner salts may possess a high bacterial content. Sometimes a combination of salt with saltpetre or sodium or potassium nitrates is used. Not only must any chance of decomposition due to the activities of bacteria be prevented ; in addition, it is most desirable that both the taste and flavour of the finished articles should not be impaired in any way. The appearance of the meat must also remain unaltered. The addition of saltpetre increases the efficiency of curing. Potassium or sodium nitrates have been found even more effective in this respect. The hæmoglobins present in the tissues of meat form a chemical combination with the nitrate. A bright red coloration results. This is more attractive than the dull grey colour produced when meat is treated with salt only. A further advantage is that bacterial development is partially inhibited by the nitrates. A certain proportion of the organisms present may be capable of converting the nitrates into nitrites ; these latter salts also assist in preventing spoilage. It has thus become a common practice to add a small amount of sodium nitrite to the salting mixture. Care must be taken when this substance is used as nitrites should not be present in a greater ratio than 200 parts per million. The employment of the dry-salting method not only inhibits bacterial development but dries the material so treated. Sugar usually forms part of the mixture. While it exerts little preservative action, sugar assists in improving the flavour of the meat. During the period when salting or pickling is in progress osmosis occurs, a slow diffusion taking place throughout the body of the meat, displacing some of the soluble albuminous matter, which is unavoidably wasted.

When dry-salting is practised, the mixture as mentioned above is well rubbed into the meat undergoing treatment. Only small portions of beef or mutton are at present dry-salted, although pork carcasses are treated in this manner for the production of ham and bacon. In the case of bacon manufacture, after the sides have been well rubbed with salt they are covered with fine saltpetre. They are then stacked one upon the other, rind downwards, in curing rooms which are maintained at relatively low temperatures, a heavy layer of dry salt being placed between each piece of meat. A certain amount of brine is formed during this process. This is due to the carcass moisture emitted from the tissues. Bacon may take from two to several weeks to dry cure, according to the method employed, the sides being removed and washed in water at a temperature of 70° F. When curing has been completed, they are wiped and trimmed. Bacon may be pumped with brine before being salted. In the case of hams, one of the most valuable pork products, it is usual to immerse them in brine for twenty-four hours. Alternatively, the pickling liquid may be pumped into the fleshy parts of the meat by means of a long hollow needle, the liquid acting as a preservative. This process is followed by dry-salting, the cut surfaces being sprinkled with salt and saltpetre. Each ham is then embedded in salt, the shank end being placed downwards and remaining in the preserving material for three days, after which it is taken out and pressed. Salting is continued for a further fifteen days, when curing is complete although hams are usually hung in canvas bags for some time to mature. Both bacon and hams are frequently smoked after salting, the methods by which this process is carried out being set down on pp. 83 and 84.

Pickling

The composition of pickling solutions varies. As a general rule, they follow on the lines set out for dry-salting mixtures set out on p. 80, with the addition of water to form the solution. The water employed for brine making should be sterilised by boiling before use. Pickling solutions should have a pH value of between 5 and 6. If this is reduced, meat treated in this way becomes tougher and there is no proper colour fixation. If the pH value is higher, i.e. between 7 and 8, the meat will be soft and gelatinous. All types of meat can be dealt with in this manner, the sale of salt beef, mutton or pork increasing rapidly prior to the War. As previously indicated, osmosis is produced in the tissues of the meat being treated. This is a slow process, and decomposition may occur before bacterial growth can be inhibited. For this reason the pickling solution is sometimes introduced into the tissues by *pumping* in order to accelerate the change and prevent decomposition. This is particularly desirable in the case of hams or fatty meats, in which penetration of the solution would tend to be slow or uneven. Pumping is carried out mechanically, perforated needles or a hollow tube being introduced into the tissues. The pickling solution is forced through these tubes by means of a pump, operated either by hand or foot. In the case of a piece of meat which contains a proportion of bone the needle is usually inserted along the bone, as at this point decomposition generally develops first. If lean meat is pickled it may become very dry following processing. It is extremely important that every effort should be made to distribute the pickling liquor in a uniform manner throughout the tissues so that the preservative reaches every portion and, in particular, it is necessary that the arteries be pumped. In spite of the universal practice of introducing the liquor into the tissues by this means, there seems to be some differences of opinion as to its value.

A common method of *pickling* is to immerse the meat into a vat of the liquor. Any meat intended for this type of treatment should be thoroughly cooled prior to immersion since, if the least trace of heat is allowed to remain, it may be sufficient to encourage putrefaction. This is particularly noticeable in the case of hams and sides of bacon, causing what is commonly termed " bone taint." The development of this condition is due to failure to cool the meat sufficiently before treatment was begun. The pickling liquor is generally stored in oak tubs which may become slimy when they are difficult to clean. Perforated lids are provided so that the meat in the containers may be suitably immersed during the whole process, weights being placed upon these lids for this purpose. In some cases tanks manufactured from slate slabs are employed. This form of container possesses the advantage of durability and ease of cleansing. For the small butcher, a glazed, earthenware vessel is satisfactory. Concrete vats are also used but the cement content may be attacked by acids in the meat. Vats used for pickling should be stored in a cool place and the temperature should be kept down to 40° F. if possible. The tops of the vats should be ventilated but protected against rodents, while a drain outlet should be provided at the lowest point.

The liquor required for pickling treatment has already been described on p. 81. The basic constituents are salt, sugar and saltpetre, often with the addition of sodium nitrate or nitrite. While salt will check bacterial growth, it will not destroy pathogenic organisms unless the process is continued for a lengthy period. According to Ostertag, however, trichinæ and cystercerci are rendered harmless by pickling operations, while it has been reported that anthrax spores, tubercle bacilli, coliform types of organisms and pyogenic streptococci have been slowly killed by pickling over a period of several months. Pickling will also prevent the development of botulism toxins. Sugar assists the preservative action exerted by the salt and counteracts to some extent the harsh effects of the saltpetre, which is of particular use in producing a pleasing colour in the finished article.

During pickling operations the liquor will naturally lose its strength when fresh meat is added. Every effort should therefore be made to maintain the liquid in its original condition. A form of hydrometer which is termed a *salinometer* is employed for this purpose. If the strength of the pickle as shown by this instrument has been reduced from the optimum of 60° on the scale, it should never be left in contact with the meat for any length of time after curing has been completed. If this point is overlooked the meat will become "pickle-soaked," whilst the liquor will turn sour. If the liquor is in a bad condition or if the treatment is hurried, the meat will become spongy, may be greenish in colour and may emit an offensive odour. The time taken for the process to be completed depends upon certain conditions and varies in accordance with the strength of the brine, the total weight of meat in the vat and the weight of the individual pieces. An allowance of approximately one day for each pound of meat to be treated gives a satisfactory result. In some cases meat may be pickled in barrels. When this is the practice, the containers should be rolled in order to assist the cure at periodic intervals.

Many people prefer their meat, particularly if it is bacon and ham, to be mildly cured. For this reason large quantities are imported annually in what is termed a "green" condition. This form of meat has received a preliminary light salting only so that the article may be finished in accordance with local requirements. When mild cured meat is required, particular attention should be paid to the temperature (*a*) of the liquor and (*b*) of the storage and packing rooms. The usual temperature at which processing should be carried out is in the neighbourhood of 40° F. The employment of higher temperatures may cause the pickle to become "ropy," while any meat cured under such conditions will exhibit an uninviting appearance. Mild-cured meats are not designed for lengthy storage and should be consumed as soon as practicable after production.

The *premises* in which pickling is carried out should be carefully supervised. As with all other food premises, cleanliness is extremely important. To assist cleansing operations, floors and walls should be constructed with some hard impervious, easily-cleansed materials. Floors should always be provided with sufficient falls for drainage so that any leakages from casks or vats can be readily detected. After a vat or tank has been used for the treatment of one consignment of meat, it should be emptied and thoroughly washed with sodium hypochloride solution, rinsed with clean, cold water and aired before being used for a further batch.

The *inspection* of meat which has been salted or pickled may present difficulties because of the appearance resulting from treatment. Once the meat has been cooked, however, it is very much easier to pronounce judgment as to quality. If the meat prior to treatment was partially decomposed, it will be softer than normal after pickling, while it may be green in colour or possess a putrefactive odour. Failure to treat the meat properly, even where the original condition was sound, will cause it to have a pale appearance. It will also be slimy to the touch. Putrefaction invariably commences nearest to the bone or in the thickest portion of the meat. If this condition is suspected the skewer test should be used. It is usual to insert the skewer at the shank or under the aitchbone ; in the case of hams, insertion takes place along the femur. When testing hocks, the skewer is inserted along the blade-bone. With bacon the test may be carried out by insertion under the backbone or ribs, and in the fat of bellies and loins. If the sourness or taint is strictly localised, the affected portion can be cut away and destroyed. Stale or old salted meat is readily recognised by its hardness, toughness or shrivelled appearance. During the process some of the nutritive properties of the meat are lost. These losses include certain nitrogenous materials and a quantity of phosphorus. In spite of the losses, the weight of the meat is increased owing to the absorption of the liquor.

Smoking

Bacon and hams are very often smoked for a period after salting or pickling. This is particularly the case when these articles are produced for sale in our southern counties, where smoked bacon and ham is greatly appreciated. In the northern industrial areas bacon and ham of the "green" type appears to be preferred.

The old method of chimney curing as practised on domestic premises has almost ceased. The process of smoking is now generally carried out in special chambers constructed of brick or other impervious materials. These chambers or smoke-houses are provided with suitable ventilation in the centre of the roof. This allows the smoke to be readily drawn upwards from the base of the chamber and to come into intimate contact with the materials undergoing treatment, being finally expelled from the ventilators. Additional adjustable ventilators are often provided. These regulate the interior temperature. The meat to be smoked is usually suspended from iron bars which traverse the chamber from wall to wall. The floor should be made of concrete, with a suitable fall for drainage. It is usual to fit a regulating door at the base of the chamber to control the admission of air and so regulate the draught. In this type of plant a temperature in the region of 84° F. is employed. Higher temperatures may result in overheating and may cause the finished article to be dull in colour when cooled. The texture would also be affected. Smoking at this temperature is a slow process. In the larger establishments huge smoke-houses, several stories in height, may be employed. These structures are provided with perforated floors together with a smoke outlet in the roof. In this type of building the upper floors are loaded first, so that any moisture which condenses due to the impact of warm air on the cold meat is prevented from dripping on to the meat on the lower floors. In some smoke-houses the meat is hung on mechanical conveyors operated by an endless chain, the product slowly traversing the smoking chamber. Temperatures of 100° F. to 150° F. are in use in many of the larger plants. In the newer type of premises the temperatures are controlled thermostatically. The process is occasionally speeded up by employing temperatures in the region of 175° F. to 200° F.

When the salting process has been completed, the sides of bacon and the hams are allowed to drain for seven to ten days so that any excess of salt is removed. They are then washed, wiped and trimmed. When many pieces have to be dealt with, they are often dried by means of compressed air from a jet, this process evaporating the excess moisture on their surfaces, the presence of which would prevent complete preservation by smoking. They are then dusted over with pea meal and suspended, clear of each other, on the iron bars of the smoke-house for three to four days. In many instances bacon is dried for several hours before the actual process of smoking is commenced. Gas burners are often used as a source of heat, while a variety of woods may also be employed to produce the necessary smoke. Hardwood sawdust of a non-resinous type such as that obtained from oak timbers is generally used for the treatment of bacon. Mahogany, hickory, maple and birchwood sawdust are all employed in the treatment of hams, the type of wood used exerting a varying effect upon the final flavour. The smoking process causes the meat to shrink, the amount of shrinkage depending upon the time and temperature of the process. The preservation of meat is assisted by the dryness of the substance which results from the smoking operations, and also from the action of certain chemicals such as phenols, creosote, carbonic acid and aldehydes which are deposited upon the surface of the meat and which penetrate to some degree into the tissues, where they retard bacterial development. Smoking imparts a characteristic flavour. This flavour can also be obtained by the use of what is known as " smoking salt," a preparation produced by several salt-manufacturing companies. This substance imparts a pleasant smoked flavour to meat if it is used during the dry-salting process. In this way the need for smoking operations is eliminated. This method has not been employed on a commercial scale but has been used in the case of domestic production. It has also been successful in dealing with some meat products such as smoked sausages.

If properly smoked, meat should be firm and bright in colour. The flavour of both smoked bacon and ham will deteriorate if these meats are kept for too lengthy a period, as will also the texture. Hams sometimes possess a puffy, gas-inflated appearance, the result of smoking the improperly-cured variety. This defect may be readily detected by palpation. If discovered, the affected article should be condemned and destroyed.

CHAPTER VIII

POULTRY, RABBITS AND GAME

Poultry

Large quantities of poultry of various kinds are reared and killed annually for human food in these islands ; still larger quantities are imported from abroad for the same purpose. Certain parts of Great Britain possess big poultry populations, but it is not sufficiently understood that the magnitude of the industry is due not so much to the efforts of the larger breeders but to the innumerable small producers responsible for the greater proportion of the fowls bred and the eggs produced. The birds commonly used for table purposes are fowls, ducks, geese, turkeys, pigeons and guinea-fowls. Certain of these types, e.g. fowls, guinea-fowls and turkeys, are known as the white-fleshed varieties, the dark-fleshed poultry being ducks, geese and pigeons. Fowls are primarily kept for the production of eggs. For this reason the main trade in table birds follows from the sale of young male birds which are surplus to requirements, and from old fowls which are no longer profitable as egg producers. The growth of the laying " battery " system of egg production has brought about an increase in the number of unprofitable birds available, ready fattened for the table, as those fowls which do not produce eggs are rapidly culled from the remainder of the flock.

The main fowl-rearing and egg-producing areas are fairly widely distributed throughout the country, but are generally to be found near the large centres of population, which provide a ready market for both eggs and the unwanted birds. Chickens and adult fowls are in greatest demand, but the quantity available is considerably less than required for table use at the present time, particularly as restricted meat supplies have created an increased demand for this type of flesh. Restaurants and hotels require large quantities of poultry of various types. Because of this all types of poultry now find a ready sale at such establishments. Indeed, it is often stated that demands from these sources prevent adequate supplies of poultry from reaching the general public. Added to the general demand there are the quantities of birds specially bred and fed annually for the Christmas trade. Part of this seasonal demand is met by imports. The difficulties attached to obtaining a sufficient supply of feeding-stuffs has resulted in an inadequate yield both of poultry and eggs, although the number of birds maintained on the various premises is increasing rapidly. If the feeding-stuffs situation could be solved, much larger quantities would become available. Added to those persons whose livelihood is provided by poultry breeding and egg production, there are innumerable fowls kept on mixed farms, any profits from which are usually the perquisite of the farmer's wife. Many urban and rural families maintain a small flock of fowls chiefly for their personal use, the surplus birds and eggs being available for local distribution.

Many breeds of fowls are kept in this country, the majority of whose ancestors were originally imported from abroad. By years of breeding and crossing these are now looked upon as native breeds. The various breeds naturally possess different characteristics, certain types being maintained for special purposes. Leghorns, Minorcas and Anconas, which are small and active, are most prized for their egg-laying capacities. Owing to their small bodies their table value is limited to some extent, although the cockerels and non-productive hens are fattened and sold for food. Rhode Island Reds, Wyandottes, Orpingtons and Plymouth Rocks are very good egg producers but are not very active. For this reason they rapidly acquire flesh, and therefore make useful table birds once their productive life is over. These types are not so large in the body as Dorkings, Cochins and Brahmas, which have large bodies, full short legs and very small bones. Their flesh is soft and of good quality until they reach the age of one year, when it tends to coarsen. Because of their sluggish habits they make remarkably good table birds, although they are not very profitable as egg producers. Castrated male birds, termed " capons," are often specially fed for the table and attain a large size, their flesh being extremely tender.

If in prime condition, the meat of all poultry is firm and possesses a fine fibre. Whereas the fat of beef is mixed with the flesh, in the case of poultry this substance lies in selected areas, particularly under the skin, in the body cavity and around the intestines. Generally speaking, the flesh of fowls is pale in colour. Few red muscles are to be found, although such flesh may appear on occasion. The flavour of the flesh depends upon the food consumed. As an example, greasy food will induce an oily flavour, whilst if an excess of fish meal is fed this will produce a fishy taste. The flesh of healthy birds possesses an unmistakably fresh, clean odour, characteristic of the meat of all poultry. The market value of the bird depends upon the manner in which it has been fed. Obviously, the more nutritious the diet given the more likely is the bird to fatten readily, all other conditions being equal. Maize, oats or barley, bran and domestic green refuse together with potatoes are used for food. Maize tends to cause the fat and its overlying skin to become deep yellow in colour. Excessive fat may develop on the outside of the carcass. This is largely wasted during cooking. A further objection to excessive fat is the fact that the keeping qualities of the carcass are not improved. Some breeders add whole or skimmed milk powder to the diet of corn or wheat, depending upon the supplies available. If this substance is fed in a mash the carcass will acquire fat in the correct places, i.e. the muscular tissue, the skin will be light coloured, whilst the flesh will be tender and have a fine flavour. The method of feeding practised can make or mar the finished table bird. If birds are incorrectly or haphazardly fed, the carcass will be poor and deficient in fat, whilst the skin may be wrinkled and thin, the flesh tough and the bones protruding.

It is usual to allow birds a free range until they are ready for fattening, this process lasting from one to four weeks according to the quantity and type of food available. During this period the bird is penned so that it has practically no exercise, which would reduce its fleshiness. The substantial producers of table poultry keep the birds in " feeding batteries " composed of large numbers of individual pens. In these pens it is important that the utmost cleanliness be exercised. The batteries should be disinfected weekly, the poultry should not be overcrowded and proper ventilation should invariably be maintained. Any diseased or dead birds should be removed at once from the pens and burned. In some cases, before fattening is commenced, the birds may be starved for twenty-four hours, water only being supplied. Many breeders state that this practice yields improved results. Generally, however, as much food as will be eaten is given. If any birds lose their appetite they are killed, unless " cramming " is resorted to ; otherwise they begin to lose weight almost immediately. " Cramming " is the term used to denote the method of forced feeding which is sometimes practised, the food being forced into the fowl either by hand, by means of a funnel, or by a special machine adapted for the purpose. Fattening in this manner assists young birds to gain weight rapidly, an increase of up to 35 per cent. being common, hens gaining some 15 per cent.

Just before the fowls are due to be slaughtered it is usual to cause the birds to fast, the object being to improve the tenderness, appearance and flavour of the flesh as well as the keeping quality. Large quantities of water are given during this period. Salt is sometimes added to the water, as this helps the carcasses to maintain condition. As already indicated in relation to food animals, a bird will not bleed satisfactorily if it is gorged, excited or fatigued. A period of fasting clears the digestive tract and prevents distension. This in turn minimises the possibility of any bacteria gaining access from the digestive tract to the eatable tissues. There is also the danger that a full intestine may be broken during the dressing and its contents be distributed over the flesh. Poultry which have to be transported in a live state are not fattened before being despatched. This would affect their health and vitality and might cause considerable loss from disease and death.

Slaughter

A variety of slaughtering methods are practised, of which beheading is probably the most ancient. When this method is employed, bleeding is usually incomplete owing to the blood clotting on the severed neck, whilst the bird staggers about, bruising its flesh and spattering blood around. In some cases the neck of the fowl is wrung. This method also produces incomplete bleeding, as the tissues and blood-vessels are twisted and displaced. If the fowl is not properly bled the neck will first turn red, then bluish-red, finally becoming green in colour. Red spots will be seen on the wings, the veins adjoining the angles of the wings being clearly visible. Dark texture of the skin on the wings and hips provides additional evidence of incomplete bleeding. One of the most common methods of slaughter employed is by dislocation of the neck. Both fowls and ducks are killed in this manner. The skull is separated from the neckbone, severing the spinal cord and the jugular vein. Whilst bleeding is not complete, this method is satisfactory as, on account of the absence of exposure to the air, clotting of the blood does not take place. The necks of birds killed by this method are usually enlarged and discoloured. Poultry killed by dislocation may be dry-picked.

Probably the best method of slaughter is carried out by " sticking," a process which is immediately followed by de-braining. The bird is suspended head downwards by the feet, a sharp knife being inserted in the mouth and base of the brain to sever the jugular vein, evidence of the success of the operation being shown by the issue of blood from the mouth. The knife is then inserted through the roof of the mouth until the brain is pierced, a twisting motion being applied to the knife to destroy the brain substance. In some instances the jugular vein is severed by means of a knife inserted through the outside of the neck. All types of fowls are killed in this manner, but geese and turkeys are usually struck on the head with a stick before being hung for bleeding.

If slaughtering is carried out on a large scale, the killing room should be maintained in a perfectly sanitary condition. No slaughter should be allowed in basement rooms. A separate room should be provided for plucking the birds. Floors should be constructed of hard impervious materials and be suitably drained. The feathers, blood and stomach contents should be collected in galvanised metal containers and suitably disposed of at frequent intervals. No wooden containers should be allowed for this purpose. All tables should be provided with suitable metal tops. Ventilation and lighting should be adequate. A pure water supply is essential, together with adequate hot water for the cleansing and sterilisation of the equipment. It should also be a requirement that the premises are thoroughly cleansed within half an hour of operations being completed. Suitable hand-washing accommodation for the use of the personnel should be provided and should be regularly used.

Dressing

Once slaughtering is complete, the carcasses have to be plucked and dressed. These operations should be undertaken in a good light so that the work may be carried out in an efficient manner. Plucking may be carried out either by the dry method or following scalding. In either case the operation must be delayed until the tissues have sufficiently relaxed. When the dry method is employed one person plucks the bulk of the feathers from the body, while the smaller feathers and down are subsequently removed by another worker, usually with the assistance of a knife. Care must be exercised to ensure that the skin is not torn, as this not only spoils the appearance of the dressed birds but facilitates bacterial infection of the flesh. Dry-picked poultry keep much longer than those which have been scalded. This method of plucking is usually employed for birds which have to be transported long distances or which are to be cold stored for any length of time. If scalding is used in order to assist in removal of the feathers, the bird is held by the head and feet and is drawn through a bath of water the temperature of which may vary between 150° F. and 190° F. Care is essential to ensure that the water temperature lies between these limits. If the temperature is too high the skin will become tender, the carcasses assuming a cooked appearance. When the fathers are pulled the skin may be torn. Scalding, however, possesses certain advantages. The feathers are more easily loosened and removed, the bird appears to be plumper, while the normal yellow colour of the skin is intensified and the final appearance made more attractive. On the other hand, scalding renders the skin more easily penetrable by bacteria. The flavour is lost to some extent, while the keeping qualities of the carcass are appreciably reduced. Another method of scalding is sometimes employed. In this method the carcasses are dipped for approximately half a minute in water at a temperature between 125° F. and 130° F. This process assists in the removal of the feathers by plucking instead of rubbing, as is the usual way when the carcass has been scalded. The carcasses are similar in appearance to those which have been dry-picked, while storage results are more satisfactory. The bird to be plucked may also be dipped in hot resin or wax solution, after which it is allowed to cool. The removal of the resin or wax brings the feathers away from the carcass in one sheet. The minute feathers or down are often removed by singeing. The flame used should not deposit carbon from the smoke on the body.

Plucked carcasses should be rapidly cooled or chilled to prevent the possibility of bacterial development together with increased activity of enzymes, which may result in decomposition or flavour destruction. Two methods of chilling are employed. One of these, known as the "wet" method, has been in use for many years but is most objectionable and has nothing to recommend it. When dressing has been completed, the birds are thrown into cold water, which is often refrigerated. They remain in the liquid for periods varying from five to ten hours. The appearance of the birds is improved to some extent, as they become plumper. For this reason they are sometimes left in the water for longer periods than is really necessary in order to reduce the body temperature. The main disadvantages are loss of flavour and protein materials. The keeping qualities are reduced, as the flesh is more easily penetrated by bacteria, while dry, scaly patches may develop during storage. When dry chilling is practised, cooling takes place either naturally, by the use of cold air, or artificially, by means of refrigeration, the latter method being preferable since it is capable of control and standardisation. The temperatures employed vary between 32° F. and 36° F. If temperatures are lower, rapid escape of heat from the carcass is prevented, the outer skin becoming hardened. Before they are placed in the chilling room, the carcasses are usually hung for at least an hour in order to dissipate some of the body heat. A period varying between twenty and twenty-four hours is usually required for chilling purposes. The poultry to be chilled are suspended by the feet, free from contact with each other, in a cold room so that the cold air can freely circulate around their carcasses.

Although poultry may be sold with the feathers attached, they are more usually retailed in a plucked undrawn and uneviscerated condition. Drawing exposes the birds to contamination. Singeing, opening of the neck or body cavity and washing the internal surfaces of the carcasses after evisceration all favour bacterial infection. Further, any rupture of the intestines is likely to spread their contents, which are rich in bacteria, over the remainder of the flesh. If any rupture does take place during evisceration, the body cavity should be thoroughly washed. Although this process may reduce gross contamination, bacterial infection can easily be spread to the otherwise unaffected portions. In addition, rapid deterioration may result from this process, which should never be practised unless a rupture of the intestines has occurred.

The carcass may be either fully or partially drawn. When it is fully drawn, the head, neck, feet and contents of the body cavity are removed. The tendons at the rear of the shanks should always be removed, especially in the case of old poultry. If the bird has been starved previous to slaughter, the organs should be easily removed without damage. If the intestines are full of food, they may break. Although not advisable, the body cavity will then have to be washed out. The hearts, livers and cleansed crops, from which the grit sacs and food materials have been removed, are included with the carcasses of drawn poultry when placed on sale.

Packing and Storage

If the birds have been scalded and chilled by means of water, they should be packed in ice in barrels, the crushed ice being carefully arranged around the carcasses. When poultry have been dry picked and chilled, they are usually packed in boxes. They were formerly packed in barrels, but this method caused them to lose their shape, while heating of the carcasses sometimes resulted together with discoloration and deterioration. When boxes are used, the birds are packed in two layers in order to allow free circulation of air and to avoid undue pressure. Poultry packed in this way can be adequately cooled, while the birds will keep in excellent condition. Boxes should be manufactured from light-weight wood which is strong and free from odours which might taint the carcasses. The heads of the birds are usually wrapped in paper and folded back so that they do not come into contact with the flesh. The carcasses are laid breast downwards. Parchment paper is used to line the boxes, although in some cases the birds are individually wrapped.

Poultry should be cold stored at temperatures of 31° F. or below, as any rise in temperature above this point will reduce the keeping quality of the birds. It should be remembered that the flesh, and more particularly the skin, is not sterile. Any bacteria present will multiply rapidly unless their development is inhibited by low-temperature storage. On the other hand, excessive storage at low temperatures is not advisable. Owing to the low humidity of such storage, the moisture from the carcasses is gradually absorbed by the dry air. Dry, scaly spots may then appear. These are thought to be due to uneven drying out of the stored poultry. It is also held that the proteins contained in the tissues lying underneath the dried-out areas may be to some extent denatured, so that the lost moisture can never be reabsorbed.

Large quantities of canned chicken and other poultry are imported annually from abroad into this country, usually in a boned state. Exporting countries attach great importance to the quality of the poultry treated in this manner. All carcasses have to be inspected for condition and wholesomeness. In many cases the final product is graded in accordance with the quality of the contents of the cans.

Freezing of the birds is often carried out, particularly now that quick-freezing methods have been devised and bearing in mind the fact that frozen foods are finding a ready sale among the general public. The types of birds best suited for freezing are those which have been killed by sticking and subsequently dry picked and dry cooled. Poultry which has been subjected to the scalding process for the removal of feathers does not freeze in a satisfactory manner, as the body cells are charged with water which, when the carcasses are frozen, forms ice crystals. These crystals will disrupt the tissues and spoil the appearance of the carcasses. If the carcasses are to retain their attractive appearance, quick freezing is essential. A thin film of oil is sometimes smeared over the carcass in order to reduce the amount of evaporation. When quick-freezing methods are employed, the birds are often wrapped in moisture-proof transparent materials and placed in cartons. This procedure prevents moisture absorption and freezer burns. Poultry is sometimes thawed by the dealer by immersing in cold running water for a period of several hours. By this means the appearance and weight are improved although the keeping quality is reduced, while some of the flavour is lost. Preferably, poultry should be sold in a frozen condition, being thawed out in the home of the consumer prior to use. This step will prevent any serious deterioration due to bacterial development. Poultry which is exhibited for sale in retail shops should be protected against handling by customers, and also from flies. If the birds have been frozen, they should be hung in such a manner that they do not lie in any moisture which may be exuded when their carcasses are thawed.

Diseased Conditions

Poultry, in common with other foodstuffs, must be inspected. In dealing with live poultry the health of the birds prior to slaughter is the principal concern. Unhealthy birds are crowded into corners of market pens by the healthier ones. A trained inspector is able to recognise many of the respiratory infections to which they are subject by means of the characteristic odours emitted. Diseased birds should be removed from the pens and destroyed, the pens being afterwards cleansed and disinfected before they are again used. Healthy, live poultry should be active and alert in appearance, the eyes should be bright, the comb and nostrils dry, the feathers glossy and elastic, while the comb and wattles, when present, should be firm and brilliant red in colour. Aged birds are indicated by the dusty appearance of the comb and wattles. The feathers of such birds are brittle to the touch and dull in appearance. The feet are ragged and the claws large ; the beak is firm and hard and cannot be bent. When plucked, the thighs are unusually dark and hairy. The breastbone is hard and unbending, while the comb is thick. There is no down under the wings.

When dressed, good-quality poultry should be firm and elastic to the touch, pink or yellowish in colour, be fairly plump, with a strong skin and a fresh smell. The breastbone should be unbroken. Stale or decomposing poultry lose their firmness, become bluish in colour and exhibit a green appearance in the neighbourhood of the crop and abdomen. The skin is discoloured and breaks easily, the birds emitting a disagreeable odour. Discoloration usually makes its first appearance on the back. When undrawn birds are inspected, an incision is made under the wings or between the legs and the abdomen. The internal organs should be exposed so that the necessary conclusions may be drawn.

As is the case with most living organisms used for food, poultry suffer from a variety of diseases which may affect their value as a foodstuff. In the case of *bacterial diseases*—bacillary dysentery, fowl cholera and typhoid fever—the affected bird should be condemned in every instance. When dealing with infection due to avian tuberculosis, the carcass is condemned if the organs show signs of extensive disease ; if only the liver and intestines are infected, the carcass may be passed as fit for human consumption provided infection is slight. Aspergillosis, favus, fowl diphtheria and fowl pox are also met with and are due to *viruses*. When any of these diseases is present the carcass must be condemned, an exception being made in certain instances in the case of fowl pox. If the head only is affected in fowl pox, it is sufficient to remove this member together with the neck. Tumours are often found. When multiple tumours are present, the carcass is condemned. Localised tumours can be excised, the remainder of the carcass being available for human consumption. Several *parasitic diseases* affect fowls. These include gapes, together with roundworm, threadworm and tapeworm infections. If the carcasses are badly infected they will be emaciated and should be condemned. A number of *miscellaneous conditions* are also met with in fowls. These comprise blackhead, catarrhal gastritis, coccidiosis, impacted crop and roup. In every case the affected carcass should be condemned. Carcasses are also condemned because of dropsy, bruises, fractures, toxæmia and moribund conditions.

Epidemiology

In view of the many diseases to which poultry are subject, they may be incriminated in the transmission of disease to man. There have been numerous reports that avian tuberculosis can be transmitted. Chickens do not possess lymph nodes, organisms being therefore able to pass direct from the lymphatic system into the blood stream. Organisms may thus be present in the tissues without any of the usual signs of disease being evident. Avian tuberculosis is prevalent among poultry. Possible sources of danger to man include the under-cooked flesh of affected birds, together with tuberculous eggs (see p. 101). Cooked poultry and its products have been implicated in outbreaks of food poisoning. In the majority of cases soups, stews and salads have been the agents of transmission, providing as they do an excellent medium for bacterial growth. This point assumed particular importance when the foodstuffs concerned are left-overs awaiting further use and which have not been refrigerated. In one case reported by Ilsley a left-over portion of chicken was involved. This was consumed by a group of people who became acutely ill within six hours of the meal. *B. proteus*, together with streptococci and colon organisms, were found on the remaining portions of the meat, and also in the vomit and fæces of the affected persons. A culture of these organisms proved pathogenic to guinea-pigs. Botulism has been produced by fowl products, the most notable instance being the Loch Maree outbreak in 1922. This was due to sandwiches prepared from commercially-preserved wild duck paste. Eight deaths occurred.

Decomposition is of considerable importance, as the flesh of poultry is subject to the same types of deterioration as occur in connection with other types of meat. The muscle tissues break down into nitrogenous compounds and ammonia ; the fat splits up into fatty acids, with accompanying rancidity. These changes give an excellent indication of the general deterioration of the flesh. Decomposition occurs rapidly when chilled or frozen poultry is thawed, owing to increased bacterial development. Until sold, many poultry carcasses are moved into and out of cold rooms, a proceeding which assists in the rapid multiplication of bacteria. To avoid this undesirable possibility, poultry should be frozen and sold in this state.

Nutritive Value

The nutritive value of poultry varies according to type. It is chiefly significant for the quality of its protein, the ease with which the meat is digested and its palatability. The flesh of chickens, guinea-fowl and turkeys contain the highest percentage of protein, while goose flesh possesses the greatest amount of fat. The flesh of poultry is low in mineral content. The light meat of the breast is more tender than the dark meat of the legs and wings. The light meat is less fatty and more easily digested than its dark counterpart. There is twice as much vitamin B in the dark meat as in the light variety. Chicken livers are specially valuable as sources of vitamins A, G and C. Generally speaking, however, no significant amounts of the various vitamins are present, although canned chicken is reported to be useful as a pellagra-preventing food.

Eggs

The consumption of eggs, although substantially limited by present economic conditions, has reached very high proportions in this country. As the quantity produced at home is insufficient to meet consumer demand large quantities have to be imported annually. The difficulty in maintaining a correct balance between supply and demand is increased by the fact that there is a glut of eggs in the spring months whilst later in the year production drops, often rapidly. The production of poultry and eggs is so closely related that it is almost impossible to effect adequate separation. Whilst the rearing of poultry for table use is the prerogative of the extensive breeder, the bulk of the egg supply, both in this country and abroad, is mainly the result of the efforts expended by the mixed farmer and the small producer. The quality of spring eggs is usually higher than that of eggs produced during hot weather, as high temperatures bring about a marked deterioration in quality.

The method of distributing eggs does much to bring about a reduction in freshness. It is the usual procedure for the producer to be visited, either weekly or at lengthier intervals, by a representative of the egg-packing station, who collects the output of the fowls and later grades and packs them for distribution to retail premises. As a result eggs are no longer in a fresh condition when sold in the shops, being anything from a fortnight to four weeks old when consumed, even when produced locally. With imported eggs age is considerably greater, although cold storage is employed to offset any deterioration which may result. Normally, hens' eggs find the readiest sale, although ducks' eggs are also in demand. The eggs of other types of poultry are usually employed for rearing purposes. The term " new laid " is applied to eggs which are not more than fourteen days old. The terms " fresh " and " cooking " as applied to eggs are also recognised by the trade, the ages of both types being greater than that set out above. Eggs will maintain their fresh condition for several weeks if stored under satisfactory dry conditions. All home-produced eggs are graded and marked ; imported eggs are stamped with the country of origin.

As there is a great demand for eggs, their freshness is of particular concern to the consumer. This has brought about a more widespread interest in methods of handling than is the case with any other foodstuffs apart from milk. This has been particularly noticeable in relation to low temperatures and their relation to egg quality. The same interest has resulted in the adoption of improved methods of refrigeration. The employment of low temperatures should start at the farm, should continue during distribution and should be maintained until the eggs are sold. This is, unfortunately, not possible under present conditions of distribution. It should be remembered that the length of time which has elapsed since production is not the most reliable index of the freshness or quality of an egg. The condition should rather be viewed in the light of any biochemical or physical changes which may have taken place since the eggs were laid. If eggs are stored under suitable low-temperature conditions they are more likely to be fresher, if older, than those which have been carelessly handled and stored at warmer temperatures, even though a shorter period has elapsed since production.

An egg provides for all the elements necessary for the development of the young bird, together with a sufficient supply of food for the embryo until it emerges from the shell. The shell may be either white or brown in the case of domestic fowls, or green or greenish-white in the case of ducks' eggs. Although many consumers prefer brown-shelled eggs to white, the coloration is no index either of the freshness or of nutritive value. The real index of freshness and quality lies in the " bloom " of the shell. The new-laid egg possesses a characteristic dull appearance, due to a thin layer of protein deposited on the shell of the egg immediately prior to its being laid.

This bloom disappears rapidly during handling and storage, particularly under damp conditions. A gloss is then produced which indicates that the egg cannot, strictly speaking, be regarded as fresh. The shell of the egg is extremely thin and possesses a number of minute apertures or pores. When the protective external layer is removed or when the egg becomes damp, bacteria find little difficulty in obtaining entrance to the interior. In the same way moisture is allowed to evaporate from the interior of the shell, particularly if the eggs are stored under dry warm conditions. These pores allow air to pass through the shell to the chick during incubation. The egg is warm when laid. As it cools, the contents contract, producing a small air space between the inner and outer internal membranes. Any evaporation of the water content causes this space to expand. The size of the air cell, which should not be more than ¼ inch in depth, supplies evidence of the quality and age of the egg.

An egg consists of a yolk, amounting to one-third of the whole. The yolk is surrounded by a gelatinous albuminous layer which is pale straw colour. This layer comprises the remaining two-thirds of the contents and is known as the " white." The albumin is composed of a watery external portion and an inner portion. The inner portion is much thicker, being thickest immediately surrounding the yolk. In poor-quality eggs the normally thick white may be thin and watery. In a fresh egg it should have the consistency of jelly. The yolk varies in colour from pale yellow to deep orange. The depth of tint largely depends upon the diet of the hen. Green foods affect the colour of the yolk to a marked degree. The yolk is rich in fat and protein and contains much less water than does the white. The constituents are present in the form of a stable emulsion. Egg yolk contains vitamins A, B_1, C, D and G. The only vitamin present in the white is a small quantity of vitamin G.

Examination

A fresh egg should possess a pleasant odour when opened. The white should be clear, the yolk yellow and free from spots. Eggs which reveal stains, dirt or cracks in the shells should be viewed with suspicion. In pre-war days eggs of this type sold at a lower price because of their poor appearance and the possibility that quality was materially reduced. A number of tests are employed to demonstrate freshness. On a small scale, the *brine test* may be employed. Two ounces of salt are dissolved in 1 pint of water. Fresh eggs immersed in the liquid will sink. If the eggs are bad they will float in various positions. On shaking, a fresh egg should emit no sound. The normal commercial test is termed *candling*. This process should be carried out in a suitable room, each egg being held in the hand in front of a brilliantly-lighted orifice so that a strong light is focused upon it. This test provides comparison of the colour, density and mobility of the contents. The size of the air cell may also be noted. The egg is grasped by the smaller or pointed end and is held with the air cell upwards between the thumb and the tips of the first two fingers. It is then given a few quick turns on its long axis so that the movement of the yolk may be noted. A germ spot located on the surface of the yolk may be detected. In an infertile egg the germ spot is small and irregular in shape. If the egg is fertile the spot will appear rounder and larger. As already indicated, determination of the size of the air cell is important. If the egg is of high quality, the movement of the yolk is restricted by the firmness of the thick white. If the egg is in poor condition, the yolk is allowed more latitude of movement. If the the yolk is only dimly visible, this is evidence of quality, as a thick, firm white prevents the internal substance being clearly seen. The development of the embryo is also noticeable when the egg is candled, while blood spots may be detected. Normally such eggs are set aside for manufacturing purposes, although they are not unfit for consumption. The presence of bacterial rot and mould growth are also determinable by means of candling. Eggs of this type are rejected as unfit for human consumption. Any foreign materials appear as dark-coloured particles in the white, while cracks which may be invisible to the naked eye are clearly apparent during candling. Not only is it possible by means of this process to separate edible eggs from those unfit for consumption, but the ages of the eggs may also be differentiated. The candling of eggs before packing prevents spoiled eggs being included and so reduces losses during storage. A method of *strip candling* is now carried out in some packing stations. In this process the eggs pass over five lights—green, white, blue, white and green. Defects, blood spots and cracks are readily noticed. Candling should be carried out in a clean, well-lighted room provided with all the necessary facilities for handling the eggs.

It is extremely difficult to control the conditions under which eggs are produced on the average small farm, when egg production is merely carried on as a sideline to the major activities of the farm. With the extensive breeder, however, it is possible to ensure healthy birds, clean nests, water and an adequate supply of good food. Methods of transport and storage should be maintained in an up-to-date condition and should be improved where necessary. Because of the conditions under which eggs are laid, especially if the nests are not clean, many eggs are likely to have dirt adhering to their shells. Several methods are employed to remove such adhesions. Washing with a wet cloth or brush, soap and water, dilute sulphuric acid or even sand-blasting are the methods normally employed. Dirty eggs usually command lower prices because of their visible condition. Although cleansing will improve their external appearance, other factors are introduced which will increase the rate of spoilage or deterioration. If eggs are handled properly after such treatment, rapid deterioration can be prevented, although it must be remembered that the membranous covering will be damaged by washing or other cleansing treatment. This always occurs when eggs are sand-blasted. During this process the eggs are placed on rubber-covered rollers, which cause them to rotate. This treatment exposes their entire surfaces to a sand-blast operated by means of compressed air. The sand, after treatment, is usually recovered, cleansed and used again. Hard, dry material is rapidly removed from the shell by this means. Apparatus of this type can deal with thousands of eggs per day.

It is sometimes of value to be able to detect whether eggs have been washed and cleansed. To this end the fact that the exteriors of the shells of untreated eggs contain potassium and chlorides is utilised. Cobalt nitrate is employed in the detection of potassium ; silver nitrate serves the same purpose in relation to the chlorides. In the case of eggs which have been subjected to abrasive treatment, dye solutions such as methylene blue or brilliant green may be used for detection. These dyes stain the thin film of protein which covers the shell. The presence of any unstained spots indicates that this film has been removed. When eggs have been sand-blasted they are sometimes dipped in oil to remove evidence of the treatment. A microscopic examination of the shell will show whether or not the shells have been treated by oil. Oil-dipped eggs may also be detected by dipping the end of the egg in ether and noting the appearance of an oily ring at the edge of the evaporating surface. This test is reliable when dealing with oil-treated eggs which have been sand-blasted.

Imported eggs are required to bear a stamp which indicates the country of origin. Attempts may be made to remove these marks in order that the eggs may be sold as English. If suspected eggs of this type are examined in the screened light of a mercury lamp, a dark patch will show where the surface film has been destroyed. The removal of these identification marks is carried out by the use of abrasives or dilute acids. If abrasives have been used, the treated part will exhibit an excessive sheen ; when acids have been applied, the treated part is duller. If the suspected egg is examined under a powerful lens, traces of the marking ink will be found in the pores of the shell, even when most of the ink has been removed.

After testing, eggs are usually packed in cases containing thirty dozen or three long hundreds. Each case should yield 35 lb. of egg meat if each egg is in good condition.

Preservation

The methods of preservation as applied to eggs are numerous and vary in accordance with the quantity to be treated. In *small-scale preservation* water-glass is commonly used, the eggs being immersed in a solution of sodium silicate. This method is efficient. Eggs treated by this method may be stored for many months without any signs of decomposition. Another method requires the addition of four parts of slaked lime and one part of salt to twenty parts of water, the solution being allowed to stand for a week to clear. The clear fluid is decanted, the eggs being placed in the resulting liquid. Eggs are sometimes placed in layers surrounded by bran, and have even been rubbed with butter in order to preserve them for future use. If preserved by any of these methods, they should be stored in a cool place and not moved or subjected to violent agitation. The shells of eggs preserved in these various ways lose their bloom. If stored in water-glass they have a dull whitish appearance. Limewater causes the shells to become roughened in texture. Preserved eggs may be readily detected by applying one drop of phenolphthalein to the shell, when a purple stain will be produced.

On a large scale, several methods of preservation are employed, of which *cold storage* is the most important. If eggs are maintained at a temperature slightly above freezing point, they may be stored for many months. The cold-storage rooms should possess adequate ventilation, suitable humidity and freedom from offensive odours. A humidity of between 75 and 85 per cent. is considered most suitable, as lower humidities cause the eggs to lose moisture, weight and a little of their flavour. If the humidity is higher, mould growth on the shells is facilitated. Open circulation of air is important in the case of high humidity. Temperatures of 31° F. to 32° F. are usually employed, although lower temperatures may be used with spring-produced eggs which possess a less watery albumin. Refrigerated eggs do not retain the bloom on their shells. Excessively low temperatures must be avoided since, if the eggs are allowed to freeze, their contents will expand and burst the shells. Ventilation between the stacked cases in the cold room is important and is usually achieved by placing battens of wood between the cases so that free circulation of air is facilitated. Other foods, particularly if strong-smelling, should not be stored in close proximity or even in the same room as eggs. If this precaution is neglected, the eggs will readily absorb such odours. After several months of cold storage a typical flavour may develop. This is most noticeable in the yolk, especially when the egg is soft-boiled or poached. This appears to be derived from the air of the storage rooms. For this reason, ozone is sometimes introduced into the air-circulation system. This reduces offensive odours and limits to some extent the growth of bacteria. Eggs are rarely stored for periods longer than one year, as, even under the most suitable conditions of storage, they undergo certain biochemical changes. The proteins slowly break down with the production of ammonia, which may be detected by means of chemical methods. The acidity of the fat in the yolk is likely to increase, while mustiness, off-flavours and offensive smells may develop. For this reason only the higher grade of eggs should be cold-stored. Low-grade eggs will already have begun to deteriorate when placed in storage. Deterioration may be accelerated in these circumstances. The cleanliness and sanitation of cold stores is vitally important. When a batch of eggs has been removed, the floors, walls and ceilings should be washed down and disinfected. All litter should be cleared and the store placed in proper sanitary condition.

In Denmark eggs have been treated by the application of a *vacuum process.* The air is exhausted from the cells, the shells being thereafter thinly coated with oil and the vacuum released in an atmosphere of carbon dioxide gas. The oil is carried into the spores of the shells and acts as a seal. The eggs have a less oily appearance than those subjected to the dipping process only. Very little weight is lost during storage. As the sealing of the pores is important, the release of the vacuum in ordinary air might be just as effective as it is in the presence of gas.

Oil dipping is sometimes practised. This closes the pores in the shells and prevents the absorption of offensive odours and losses of moisture. The eggs are dipped for a few seconds into a bath of tasteless and odourless mineral oil maintained at a temperature of approximately 135° F. or higher. When the oil cools, it seals the pores of the shells. This cannot be recommended as a substitute for refrigeration, although it forms a valuable adjunct to low-temperature storage.

Treatment with *carbon dioxide gas* is also used as a means of preservation. Eggs deteriorate due to the loss of carbon dioxide. In some cases the atmosphere of the storage rooms are therefore charged with this gas. The concentration required should be such as will prevent any loss of gas from the eggs, yet not sufficient to affect any person entering the storage rooms. Eggs can be treated in this manner whilst in their cases. The effect is most potent at higher temperatures, when refrigeration is not employed. The store must be heated in such a way that the gas is not diffused excessively or otherwise wasted, since frequent charges of the gas may be necessary to prevent losses. The quality of the eggs is improved, this being evidenced by the fresh odour which is retained, by the condition of the yolk and the thick white, and by the taste and colour of the contents of the shell. The ideal conditions of storage require 85 per cent. moisture with 2½ per cent. carbon dioxide.

Frozen Eggs

Whilst trade in frozen eggs was originally the monopoly of China, large quantities are now produced annually in America and in the Dominions. In the last-mentioned areas control measures are particularly strict. Prior to the War, frozen eggs were used in the manufacture of salad cream and mayonnaise and by bakers and confectioners. They are still so used to an extent which is limited only by the quantities available from abroad. Not only is the bulk to be transported reduced and much shipping space saved, but cracked and other defective eggs, which would be otherwise unsuitable for lengthy storage in the shell or which had a low market value, can be utilised by this means.

The eggs are broken separately, smelled, placed into large metal containers and immediately frozen. These operations should take place in suitable establishments under adequate sanitary supervision. The walls and floors should be constructed of some hard impervious material. Proper drainage is essential, and an adequate water supply should be provided. Table tops should be of metal to facilitate ready cleansing. The rooms in which the processes are carried out should be well lighted and cooled, while the operators should be provided with caps and white overalls daily. Lavatory accommodation, with an adequate supply of hot water, soap and towels, should be provided for their use. The employees should be supervised to ensure that these facilities are used. Their hands and fingers should frequently be inspected. Any person suffering from illness or skin infection should be prevented from handling eggs or utensils, only those persons who have a clean bill of health being allowed to carry on the work. Medical examination before employment is to be recommended. The cups into which the eggs are broken should be made of stainless steel. This material is easily cleansed and sterilised and will not readily chip or break. The cleansing and sterilisation of utensils should be regarded as of paramount importance. Bacteriological examinations of all equipment should be frequently made, designed to determine their degree of cleanliness.

In some instances the whites and yolks are separated for special purposes. The eggs should be selected with the greatest care, otherwise one low-grade egg may spoil the entire batch, which may amount to many dozens. Eggs are usually candled and chilled before being broken. This assists in the separation of the whites and the yolks, should this be necessary. The eggs are broken by being struck with a blunt knife. If the whites and yolks have to be separated, the contents of the shells are dropped into a separator which retains the yolks and allows the remainder to discharge into a second container. Each egg is smelt to detect mustiness or other unwanted odours. Unsuitable eggs are immediately discarded. The breaking apparatus should be immediately sterilised if it has become contaminated with any poor-quality egg. The unseparated eggs or the separated yolks are then churned until a homogenous mass is formed, after which they are placed in 15 lb. or 30 lb. cans, in which they are frozen. Some eight minutes normally intervene between breaking the fresh egg and the completion of freezing. Care should be taken during all the operations to ensure that the final product is above suspicion. With the advent of frosted foods, eggs treated in this manner, free from their shells, are likely to become available for domestic culinary purposes.

Frozen eggs should be maintained at very low temperatures until they are used, since decomposition occurs rapidly after the can has been opened. Due to the fact that frozen eggs are packed in cans, losses due to shrinkage are prevented. Progressive spoilage is also avoided. Freezing temperatures are usually below 0° F., quick freezing at −12° F. to −15° F. being normally preferred. Storage temperatures are similar, ranging from 0° F. to $-5°$ F. When supplied to the baking or confectionery trade, sugar is often incorporated in the eggs. This affords additional means of preservation. Salt can also be added to egg yolk. This facilitates the formation of lumpy particles and assists smooth thawing. If the yolk which is mixed with these substances is actually frozen, the protein may become denatured. Salted yolks are used by mayonnaise makers. If both sugar and salt are added to the yolks, the freezing point of the mixture is lowered. When the eggs are to be used, they are best thawed by placing the can in cold running water. The whipping qualities of egg white are not affected by freezing. This type of egg product will maintain its quality for over one year and possess consistent uniformity. Preservatives are sometimes added. These include acetic or lactic acid, or a mixture of both. Liquid eggs are sometimes mixed with glycerine.

Dried Eggs

Large quantities of dried eggs, either in an unseparated form or as dried yolks or albumin, are imported into this country annually. These are for use primarily by the food industry, although during the shell-egg shortage substantial amounts were, and still are, used domestically and by caterers. During the War dried eggs became a culinary stand-by when shell eggs were scarce. China has always been one of the largest producers of this type of egg, but the United States of America and the Dominions manufactured large quantities during the war years. These latter countries continue to send us a high-quality product.

The eggs are broken for drying in a similar manner to that used in freezing, the yolks and whites being separated as desired. The egg yolks are sometimes churned to ensure a smooth mixture, after which they are dried by the spray process, the liquefied yolks being pumped under pressures of between 1,500 lb. and 3,000 lb. per square inch into a heated conical chamber at temperatures ranging from 160° F. to 220° F. The moisture is rapidly extracted, the dried yolk falling to the base of the chamber in the form of a fine powder. Another method is to run a thin film of the liquid yolk on to aluminium belts which pass through heated chambers, the dried product being scraped off in flakes at the exit end. Steam-heated rollers are also used for drying purposes. These methods are also employed for unseparated eggs. Dried eggs do not require the addition of preservatives.

The whites, or albumin, are collected in vats, where the liquid is allowed to ferment at 70° F. for between thirty to sixty hours. In some cases citric acid or acidified pepsin solution is used to accelerate the process. Fermentation retains the whipping qualities of the reconstituted eggs and thereby increases their value to the food industry. When fermentation ceases, the clear liquid is drawn off. The acidity which has developed is then neutralised by the addition of 2 ounces of aqua ammonia and 3 ounces of alcohol to each 100 lb. of white. The liquid whites are clarified and allowed to settle. The liquid is then dried in pans or on trays placed in heated rooms, the period required varying from thirty-six to sixty hours. Drying may also take place on belts passing through heated tunnels at temperatures in the region of 120° F. This temperature is maintained for eighteen hours, being afterwards raised to 140° F. for a further twenty hours. In the latter method drying is speeded up, the final product having a flaky appearance. These temperatures must be strictly controlled. If this precaution is not observed, the albumin may coagulate, as the temperature at which this change occurs is only a few degrees above the drying temperature. Spray drying is not widely employed for the production of dried egg white. This process tends to destroy the whipping properties when the substance is reconstituted with water. Albumin is used for meringues, marshmallows and similar products. Its whipping qualities are important. Dried yolks and unseparated eggs are largely used by cake and biscuit manufacturers, and in prepared cake mixtures. The ice-cream trade also takes a substantial proportion of the available supply. From a culinary point of view, the dried unseparated egg makes excellent omelettes. Any dishes made from dried eggs should be effectively cooked by being brought to boiling point immediately after reconstitution.

Dried eggs will retain their good quality provided they are maintained in a dry condition. Damp conditions rapidly cause deterioration. A cool atmosphere is also necessary for storage. If the substance is not protected from the air, oxidation will result.

Nutritive Value

The nutritive value of eggs is high. They possess an almost similar quantity of protein to many types of meat, with the same percentage of fat. Their mineral and vitamin content is high, but there is little carbohydrate present in their composition. The bulk of the fat is contained in the yolk. Small quantities of mannose, glucose and galactose are present, associated with the protein content. The composition of stored eggs varies from that of the fresh variety. Changes are caused by osmotic action through the membranes of the egg and by evaporation of the moisture content through the pores of the shell. The flavour, composition and nutritive value of eggs depends upon the producing fowls and upon their food supply. The fatty acid percentage may be affected, and the vitamin D and iodine content increased, if these substances are added to the fowl's diet.

Eggs, like milk, form a completely nutritive food for the young. Whilst neither food is perfect in itself, the quality of the constituents is very high. The proteins present in the yolks and whites of eggs are adequate to sustain growth and reproduction, and possess a further value in that they improve the efficiency of other food proteins. Egg yolk is particularly rich in iron and phosphorus. Generally speaking, the calorific value of eggs is approximately equivalent to that of meat, weight for weight. Whilst not quite so nutritive as meat, eggs are stated to have a greater nutritive value than that of any single food other than meat.

Feeding experiments have shown that the general health of children given eggs in addition to other foods is high, and that there are no constipating or digestive disturbances. It should be noted, however, that some individuals appear to be allergic to eggs, a form of eczema being one of the resulting symptoms. The raw yolk causes no digestive disturbances ; egg whites digest more readily when cooked.

The vitamin content of eggs has already received brief mention. The vitamin A and D content of the yolk is not high, although the quantity can be increased by suitable feeding methods. Dark-coloured yolks usually contain the highest percentage of vitamin A. The percentage present does not appear to be diminished to any appreciable extent by cold storage. The vitamin D percentage may vary with the season. By adding this vitamin to the food or by irradiating the hen with ultra-violet light, the final quantity may be increased. Eggs contain a higher percentage of vitamin D than does any other foodstuff. The vitamin D present in eggs is not impaired by cold storage or by boiling for the table. The B_1, or thiamin, content is approximately equivalent to that of milk or cereals, but there is a slight loss when eggs are boiled hard. The vitamin G content is high, while vitamin C is almost entirely absent.

Eggs form a useful food which can take the place of meat. They are specially valuable when used in conjunction with other articles to form a balanced diet. The faulty storage of eggs will cause their nutritive value to be reduced. Though sterile when produced, the bacterial content may substantially rise due to mishandling. This increase in the bacterial content results in the production of enzymes which in turn cause the proteins to break down. Decomposition of the carbohydrates and splitting of the fatty acids also occurs. Deterioration is most rapid during the first few months of storage. As the contents deteriorate, palatability is reduced.

Epidemiology

Eggs are significant carriers of pathogenic organisms. All the salmonella types of organisms have been isolated at various times from the eggs of birds affected with enteritis. It is also held that the causative organisms of typhoid and paratyphoid fevers, as well as other forms of food poisoning, may be present in eggs obtained from diseased birds. Hens' eggs are normally sterile, although the eggs of a diseased bird may become infected before they are laid. The total number of organisms obtaining entrance to an egg in this way is small under normal conditions, but the yolk forms an ideal breeding ground for bacteria. The numbers originally present may rapidly increase unless the eggs are stored under cool conditions. Salmonella organisms are not destroyed unless the egg is boiled for at least eight minutes and is afterwards allowed to lose its heat slowly. The normal period of boiling or frying is therefore not sufficient to destroy such organisms. An outbreak of salmonella infection due to chickens' eggs was reported by Watt. Twenty-eight cases occurred aboard a merchant vessel, *S. montevideo* being isolated from members of the crew, seven of whom exhibited no signs of illness. Mayonnaise used for salad dressing was implicated, this substance containing raw eggs. The causative organism was also isolated from eggs stored in two cases aboard the vessel. The Holborn district of London experienced a brisk outbreak during 1950, over 500 cases being reported. Egg dressing was again implicated.

It is possible that eggs produced by tuberculous fowls may contain the organisms responsible for avian tuberculosis. Whilst the danger of contracting tuberculosis from eggs does not appear to be great—there is no direct evidence that avian tuberculosis is pathogenic to man—these organisms have been isolated from the body discharges of tuberculous persons. The possibilities of infection in this manner would thus appear to call for further investigation. Considerable difference of opinion exists regarding the time required to destroy such organisms by cooking. Various investigators have reported that six to twelve minutes' boiling are required. In soft-boiled eggs the organisms have been found between the soft and firm portions. On the other hand, it has been stated that all the organisms are destroyed if the egg is hard-boiled. The consensus of opinion holds that boiling for more than ten minutes is necessary, slow cooling being again an important factor.

Ducks' eggs have long been regarded as a potent means of spreading infection. It is thought that the high incidence of disease which follows the consumption of infected ducks' eggs is due to the conditions under which the eggs are often produced. Ducks are filthy in their habits, and in dealing with a solitary case of food poisoning inquiries in this connection should be made. There is little chance of preventing the infection of ducks' eggs except by maintaining the birds under strictly clean and sanitary conditions. If ducks are allowed to wander at will, as is so often the case, they are particularly prone to acquire infection, which is eventually transmitted to their eggs. A thorough cooking of all ducks' eggs is apparently the only sure safeguard. Labelling to this effect was compulsory in Germany before the War, where many outbreaks of disease have been traced to this source. The practice of warning labels might be adopted with advantage in this country.

Dried egg, particular when stale, has been the cause of severe attacks of gastro-enteritis. Infection in this case has normally occurred after reconstitution, usually in the home of the consumer. As might also be expected, frozen eggs have also been implicated in disease outbreaks. Frozen eggs are, on occasion, highly infected with pathogens, bacterial development being extremely rapid when they are thawed.

When in 1943 it became apparent that food-poisoning outbreaks were on the increase, investigations were made into the possible cause. Available evidence showed that two organisms had appeared for the first time in this country. These organisms—*S. orianienberg* and *S. newport*—had been associated with food poisoning in the United States of America but, as already stated, were until 1943 unknown in Great Britain. It was eventually discovered that the only phenomena peculiar to 1943 which could possibly be associated with an altered bacterial flora so far as foodstuffs were concerned were : (*a*) the arrival of large numbers of American troops in these islands and (*b*) the advent of dried eggs in substantial quantities.

Further investigation exonerated the American troops, leaving dried eggs as the presumptive factor of infection. Bacterial examination of many batches of dried eggs revealed the presence of *S. orianienberg* and *S. newport* in a sufficiently large number of instances (approximately 70 per cent.) to warrant the conclusion that this incidence was directly concerned in the rising incidence of food-poisoning outbreaks. Subsequent investigation provided corroborative evidence.

It must be remembered, of course, that dried eggs, in common with reconstituted powders of a similar character, are only dangerous when certain conditions are fulfilled. First, pathogenic organisms must be present in the original powder. Second, these organisms must be afforded an opportunity to multiply. The relevant factors governing such opportunity comprise temperature, moisture and time. Multiplication will seldom, if ever, take place in a sealed container ; it is also unlikely that bacterial growth will assume dangerous proportions in dried egg powder to which water has not been added, even when the powder has been removed from its container. It will thus be seen that the danger point is reached when dried egg powder is reconstituted with water and allowed to stand at room temperature or higher before being cooked. If for any reason reconstitution has to take place, the resulting mass should be placed in an ice-box or refrigerator until required for use.

Tests have proved that various pathogenic organisms can obtain entrance to the contents of an egg through the shell after it has been laid. It was thought that the removal of the protective film of protein and salts produced open pores in the shell through which bacteria were able to pass. This explanation is not, however, strictly correct. If the shells are allowed to become soiled with fæcal matter, and if they are stored under damp conditions, infection may occur whether or not the shells have been washed or cleaned. Eggs should always be kept clean and dry to prevent the possibility of bacterial invasion. When storage conditions are damp, moulds frequently develop on eggs, penetrating the interior. The musty odour of eggs has been traced to the organisms *Achromobacter perolens*, which grows at low temperatures. Infection can occur through the shells at cold-storage temperatures.

Rabbits

Large quantities of wild rabbits are consumed in this country each year. As the result of advice tendered by the Government during the War, many people reared the tame varieties for the table, a practice which is continuing to some extent at the present time. Wild rabbits are either shot, trapped or netted. The supply has been somewhat reduced since 1939 owing to their destruction as agricultural pests by gas and other means, and because of the increased value of the pelts, for which many animals have been killed.

The flesh of the rabbit is tender and nourishing. Rabbits are in season from September to March, but are retailed throughout the year, although the majority of those sold out of season are imported. The weight of a good live rabbit varies between 3 lb. and 4 lb. before it has been dressed. A number of domesticated rabbits are also sold. These are larger than the wild variety, while their flesh is whiter. Large quantities of rabbits are imported from the Continent. These animals are again larger than our wild native type. Frozen rabbits are also imported from America, Australia and New Zealand, although this traffic has declined to some extent. Frozen rabbits are usually eviscerated and cleansed before despatch to this country. They are graded either first or second grade. They are packed in crates, cold-stored and transported either in a chilled or, more usually in a frozen condition. Large quantities of tinned rabbit have also been imported during the last few years.

Cases have been recorded where cats have been packed with imported rabbits to be sold as the genuine article. There are certain obvious differences in the carcasses. If the body of a cat were exposed for sale, it would naturally be skinned and dressed, whereas rabbits are usually exhibited with the skin attached and the viscera removed. In the rabbit the kidneys are chocolate-brown in colour and regular in shape. The right kidney is fixed and is approximately 1 inch nearer the head than is the left kidney, which is floating. The kidneys in the cat are both fixed and lie opposite each other, while each organ is marked with clear superficial veins. The liver of the rabbit possesses four lobes ; the cat's liver has seven lobes. The cat has an extra pair of ribs and a rounder skull.

The principal diseases affecting rabbits are *coccidiosis*, *Cysticercus pisiformis*, the cystic form of *Tænia serrata* in the dog, *Cysticercus serialis*, the cystic form of *Tænia serialis*, and *tuberculosis*. Coccidiosis is commonly met with. The disease is usually localised in the liver, this organ when affected being condemned. If the carcass is emaciated the whole should be destroyed. With cysticercus infections the cysts can usually be removed.

Again, if emaciation is present, the entire carcass is rendered unfit for human consumption and must be condemned. Wild rabbits are not susceptible to tuberculosis but, as with other animals, the domesticated type may be affected. A form of pseudo-tuberculosis is also found. As emaciation usually accompanies both these diseases, the carcasses should invariably be condemned. The infection of wild rabbits with *Pasteurella tularensis*, which causes tularæmia in man, has been reported from America, human infection occurring from contact with the raw flesh and blood of the affected animals, and from their fur, during dressing operations. The consumption of insufficiently-cooked rabbit meat containing *P. tularensis* can also cause the disease. When infection is present, the liver is covered with numerous small round spots. The causative organisms will be found in parts of the body. Human infection occurs through cuts and abrasions, the attack beginning within three days. Full recovery seldom occurs under two months. If the meat is thoroughly cooked there is little danger of infection. If this is not done, the bone marrow may not be sufficiently heated and will allow the organisms to survive. The fur of the rabbit may harbour *P. tularensis*. If the presence of *P. tularensis* is suspected, suitable disinfection of the hands should be carried out. Rabbits are also liable to *mange, favus* and *ringworm.*

As with all other types of food, *inspection* is important. If the animal is in good condition and fresh, the flesh is firm and elastic, slightly moist and pinkish or bluish in colour. The kidney fat should be abundant, the carcass emitting a fresh, clean smell. The carcass should be free from bruises ; the abdominal fat should be sweet-smelling. Decomposition is denoted by a wet, flabby condition of the flesh, a bluish-grey colour and by the offensive odour emitted. This is readily noticeable. If the carcass has not been skinned and dressed, staleness may be detected by dullness of the eyes, a sticky, slimy appearance of the interior cavities and that fact that patches of fur can be easily removed. The flesh of imported wild rabbits is moister and rougher than that of the native variety. The Belgian rabbit has a white flesh which possesses less flavour than the wild variety. The fat is yellowish in colour. Carcasses of this type are sometimes affected with white moulds somewhat similar to those found on chilled meat. Such affected carcasses decompose rapidly and soon become unfit for human consumption. In some instances mouldy rabbits emit a musty odour ; this condition is due to prolonged cold storage and is readily detected after thawing is complete. Young animals have stumpy necks, thin, soft ears and smooth, sharp claws. With age the haunches thicken, the ears become dry and blunt and the claws ragged.

Game

There are two types of game, furred and feathered. Game birds raised in this country are subject to close seasons. Imported game birds are sold throughout the year. Both types may be sold when in the initial stages of decomposition. When in this state they are said to be " high." Such birds cannot be seized or condemned on this account, their meat being regarded as a delicacy.

The two principal types of *furred game* are deer and hares. *Deer flesh*, known as venison, is dark blood-red in colour. The fat is perfectly white, closely resembling that of mutton. It is often excessively bruised or hæmorrhagic due to hunting prior to death. So that it may become " high," venison is generally hung in a cool draughty storage place until the desired condition is attained. Venison from old animals is dry, strongly flavoured and coarse. If staleness is suspected, the skewer test for taint can be made. *Hares* are similar in appearance to rabbits, but larger. The fur is generally light buff in colour, but is white on the stomach. The hind legs and ears are larger than those of rabbits. Hares should not be more than one year old when eaten, otherwise the flesh will be indigestible. As with venison, the degree of decomposition allowed depends upon individual taste. The hare suffers from similar diseases to those which affect rabbits.

Feathered game includes pheasants, partridges, grouse, snipe, ptarmigan, blackcock, woodcock, wild duck, plover, quail, teal and widgeon. As with furred game, a " high " condition is appreciated by many consumers, birds being frequently offered for sale in a semi-decomposed condition. The usual practice is to condemn the bird when the flesh is green, soft, flabby and putrid or when maggots are present. Several diseases affect game birds. Pheasants are prone to *tuberculosis* and *enteritis* ; grouse suffer from what is known as "*grouse disease*." Birds affected in this way show hæmorrhages of the intestines, with congestion of the lungs and liver. All types harbour parasites. Judgment in the case of affected birds normally depends upon the condition of the carcass.

CHAPTER IX

FISH AND FISH PRODUCTS

The present world shortage of meat has focussed greater attention upon fish and fish products as a means of supplementing existing sources of protein. It is perhaps fortunate that, being an island country surrounded by waters in which the fish population is high, the people of Great Britain have for centuries been able to make extensive use of fish as an article of diet. In the past, transport and storage difficulties prevented the fullest use being made of this valuable source of food. The production and distribution of fish of all types is now one of major industries. Consumption has increased to such an extent during the past fifty years that the fishing vessels have been forced to make more lengthy voyages in order to obtain the quantity necessary to supply the increasing demand. There is, indeed, a real danger that the seas in the immediate vicinity of our coasts may soon be over-fished. Scientific knowledge is being increasingly applied with a view to maintaining a sufficiency of edible fish in home waters.

Fish has never played the prominent part in our diet which it has done in other countries less favourably placed for the production of meat. During the last twenty years, however, increasing attention has been paid to the value of fish as an article of food, and we have been forced by world conditions to accept it as a valuable additional source of protein. Religious customs have also contributed to increase the demand, particularly as improved methods of transport became available. Finally, the mistaken belief once held that the food value of fish was inferior to that of meat has been dissipated by improved educational methods.

There has always been an element of conservatism amongst fish eaters, many of whom will only eat certain types. The excessive demand for these particular varieties has doubtless helped to produce shortages of various kinds. Scientific knowledge has helped to popularise many previously unknown or unwanted types, but even now there are many more kinds of fish in the sea than are utilised for food. Some types of fish are avoided by reason of the fact that the methods required for their proper handling between sea and table are not sufficiently realised. Others are thought to possess poisonous properties ; many more are not fully utilised owing to prejudice on the part of the consumer. Increased research into the food values of fish and fish products has assisted in breaking down many of these prejudices, although much still remains to be done.

The chief fishing grounds around the British Isles are the North Sea, Iceland, the west coast of Scotland and parts of the Atlantic Ocean adjacent thereto. Further afield, Bear Island and the White Sea, together with the Faroe Islands, all yield their quota. There are also large quantities of fish caught in the shallower waters nearer our coasts. The bulk of the fish caught is taken in the relatively cold waters which lie between the fortieth and sixtieth parallels of latitude. Strangely enough, tropical and sub-tropical waters yield only a small proportion of the total edible fish consumed annually. Many types of fish spawn in the shallower waters near our shores or in rivers, and feed in those areas where plankton is available for their development. The salmon is an instance of this type, maturing at sea and travelling into the fresh-water rivers to spawn. The young fish travel back to the sea and, after they in turn mature, invariably return to the same river at spawning time. On the other hand, the eel, which normally inhabits fresh water, travels to the depths of the sea in order to spawn. The young eels return to the rivers to live and mature until spawning time once more returns, when they travel once more to sea. These are perhaps unique instances, as the majority of fish are born and live in one particular habitat, either fresh or salt water.

The rivers of this country carry down to the sea large quantities of food suitable for fish life. For this reason the coasts of Britain and Western Europe have always been noted for the abundance and quality of the fish available. Fish are always to be found where food is abundant, but the water temperature, the salinity of the water and its dissolved oxygen content are equally important. The shallow-water areas are most suitable for sustaining marine life of all kinds, as sunlight is able to penetrate to some extent, thereby assuring a plentitude of marine plants and plankton to supply the needs of the small fish.

Types of Fish

Fish are cold-blooded vertebrates which vary considerably in shape and size. When they are removed from their natural element they quickly perish. They fall into distinct categories. The round type, found both in fresh and salt water, possess an eye on each side of the body and live at varying depths in the water. The other variety, known as flat-fish, usually live near the sea bed. When young they possess an eye on each side of the head. As they mature the conformity of the head changes until both eyes are on the upper or dark side of the body. Flat-fish swim with the dark side uppermost, the white-skinned, or underneath, portion being nearest the sea bed. Fish are provided with a number of fins which enable them, with assistance from the tail, to propel themselves.

From the edible point of view, there are four distinct classes of fish. Haddock, cod, flounders, brill, plaice, sole, turbot and whiting are examples of the white-fleshed variety, whereas salmon and salmon-trout possess a flesh which is reddish or pinkish in colour. Mackerel, sprats, herrings, pilchards and sardines are notable for their greasy or fatty flesh. Shell-fish such as crabs and lobsters have white, solid flesh, but there are other types of shell-fish, such as oysters, mussels and cockles, which are entirely different to the other varieties.

There are innumerable varieties of edible fish, both of the fresh- and salt-water types. Of the salt-water round varieties, cod, haddock and hake are most common, although coal-fish, ling, pollack and whiting are also eaten and are members of the same family. The blenny family is represented by the catfish and the dogfish, and the mullet family, including the red and grey gurnard together with the red and grey mullet, is not so common. Mackerel are entirely separated by appearance from these varieties, as are the sea bass and sea bream, which are members of a separate family. The herring family includes herrings, pilchards, sardines, shads and sprats. All are popular types. The salmon family, some of whose members inhabit both fresh and salt water, includes the grayling, salmon, salmon-trout and smelt. Also inhabiting both fresh and salt water is the eel. The conger eel, a member of the same family, is solely a salt-water variety, as is the sturgeon. The salt-water flat-fish are popular with consumers and find a ready sale.

Of these the brill, dab, flounder, halibut, lemon sole, megrim, plaice, skate, sole, turbot and witch are caught in large quantities, while angler fish and John Dory are sometimes seen. The fresh-water varieties include salmon and salmon-trout, grayling, common trout, pike, perch and chub, these being the main edible types.

Fishing Methods

The methods employed in catching fish vary considerably. Probably the most common method is the use of the trawl. This is employed for catching a substantial portion of our sea fish. The *otter trawl* is a large conical, bag-shaped net which is dragged through the water at a speed of two to three knots per hour. Two otter boards are used to keep the mouth of the trawl open. From this point two wire ropes or warps extend to the fishing vessel or trawler. When the trawl is pulled by the forward motion of the boat, the mouth of the net is widely opened. The mesh of the net varies from 3 inches square near the mouth to about 1 inch square at the extreme or cod end. Fish are collected in the net as it moves forward over the sea bottom. After a varying period, depending on the prospect of a good catch, the net is hauled up, the cod end cut and the fish are shot out on to the deck of the trawler.

For herrings and pilchards, which swim in shoals, the *seine net* is used, the size of mesh being smaller than that of the trawl. The fish attempt to swim through the net but are caught by the gills and cannot withdraw. The upper portion of the net is provided with large cork floats, the lower portion being weighted in such a way that it hangs in the water like a curtain, preventing the free passage of the fish. Large catches of herrings are made by this means, the net being dropped overboard from the herring drifter and extending for considerable distances. When the net is hauled, the fish are detached from the net on to the deck of the drifter. Another form of net, bag-like in shape, is used in rivers for catching eels, which swim into it and are caught in the pocket at the far end. A net similar to the seine net is also used for salmon fishing in estuaries and rivers, and also for off-shore fishing from the beach.

Large numbers of fish are caught by *deep-sea lines* which are lowered from fishing vessels. These lines may be of considerable length, being provided with a large number of baited hooks. Fish caught in this manner are considered to be of a higher quality than those caught in the trawl. *Pots* are used for crabs and lobsters, and *dredges* for oysters and shell-fish, while fresh-water fishing is mainly carried out by means of *rod and line*. Shrimps and prawns are generally caught in *fine-meshed trawl nets*.

When fish are caught by boats near the shore, they are usually placed in baskets or other containers. As the distance to be transported is normally short, no means of preservation are employed. The larger trawlers, which may be absent from port for periods varying from one week to a month, or even longer, according to the distance to the fishing grounds, must necessarily employ ice or other means of refrigeration to preserve the catch. Many types of fish are subject to intestinal putrefaction unless they are gutted as soon as caught. These types, which include cod, haddock, hake and halibut, are so treated before being packed in ice or refrigerated in the hold of the trawler.

During and since the War it has been the practice to behead fish immediately after they have been caught. This practice enables the capacity of the trawler to be increased by as much as 25 per cent. There are certain obvious disadvantages attached to this practice. There is leaching from the cut surfaces and the fish remain on deck for a longer period than would otherwise be the case, thus aiding more rapid deterioration. The beheaded fish are often crushed as the support given by the bony structure of the head is lost when that member has been removed. Invasion of the cut surfaces by bacteria is assisted and there is, in many instances, likely to be considerable additional waste as the cut surfaces have to be trimmed by the merchant before the fish can be sold. There is also the loss of animal feeding stuffs which could be manufactured from the heads now normally thrown overboard. In addition, each voyage is now lengthened by several days, due to the greater fish storage capacity available. Voyages are quite lengthy enough and any steps taken to increase the period between catching and landing should be viewed with doubt. After gutting, the fish are usually washed in sea water before being cold-stored. While chopped ice is commonly used for storage purposes, a number of the larger vessels have recently been provided with mechanical refrigeration. This enables the fish to be more perfectly preserved until landed at port. This is the ideal system but, because of the expense entailed, it has not yet supplanted the use of ice.

Care should be taken when fish are caught to ensure that their skins are not damaged in any way. Fish are subject to rapid deterioration owing to bacterial infection through such wounds. The appearance and quality is lowered and the market value reduced. Damage during unloading should also be avoided. For this reason, forks for lifting fish should not be employed. Normally the fish are hoisted from the hold in baskets or boxes and laid on the dockside market for inspection and sale.

Characteristics

When fish are *fresh*, the eyes should be full and bright and the flesh firm, solid, opaque and elastic to the touch. If pressure is applied by the fingers, the flesh should not pit or appear gelatinous or watery. Fresh fish should be full-scaled, the gills should be clean and bright red in colour, and there should be no unpleasant odour. If the fish have not been packed in ice, they should be reasonably stiff, the flesh should not be easily separated from the bone and the abdominal cavity should be clean and not discoloured. Fresh fish will sink if placed in water. Round fish retain their shape if fresh, girth rather than length being the most desirable property. In the case of flat-fish, the skin should be smooth, unblistered and adherent to the flesh.

Stale fish exhibit a reddish discoloration along the backbone, the intensity of the shade indicating the length of time which has elapsed since the fish were caught. They also emit an offensive odour. In the case of fresh fish, odour is absent. The covering slime may occasionally emit an offensive odour. When this is washed off, the fish may be found to be quite wholesome. The flesh of stale fish will strip easily from the bones, the abdominal walls having a red, soft, pulpy and jelly-like appearance, with commencing discoloration and a tainted odour. In this condition the flesh will be alkaline to litmus. After twenty-four hours the eyes begin to lose their lustre. In three to four days they become grey and sunken. The gills are discoloured and slimy after the third or fourth day, while the flesh will pit readily if pressure is applied. Cases have been recorded in which the gills of stale fish have been artificially coloured with animal blood to provide an appearance of freshness. If suspended by a fin in the middle of the back, a fresh fish will balance properly. If the tail droops, this demonstrates the degree of unsoundness, as rigor mortis persists longest nearest the tail. Stale fish will float readily in water.

Inspection

Before dealing with the inspection of fish, certain *close seasons* for catching and sale should be noted. These are as follows :—

Salmon	Between August 31st and February 1st
Fresh-water trout	Between August 31st and March 1st
Oysters (native)	Between May 14th and August 4th
Oysters (deep-sea)	Between June 15th and August 4th
Fresh-water fish	Between March 14th and June 16th
Mussels	Between May 1st and August 30th

It should be noted that there is no close season for the salt-water varieties other than for certain types of shell-fish. Fish are normally in the optimum condition immediately before they spawn. During the process of spawning they become flabby, thin and wasted. For some time afterwards they are unfit for human consumption and should not be used for this purpose. Edible crabs carrying spawn and soft-shelled crabs are not allowed to be sold.

Fishes of the following sizes are regarded as being *immature* :—

Hake	If less than 13 inches in length
Haddock and whiting	If less than 9½ inches in length
Plaice, dabs, witches, lemon soles and megrims	If less than 9 inches in length
Crabs	If less than 4¼ inches across the broadest part of the back
Lobsters	If less than 8 inches from the tip of the beak to the end of the tail

Immature fishes should not be caught and sold. In the past this was a very common practice, considerable wastage of fish life resulting. If this wastage had been allowed to continue, a shortage of suitable fish for the retail market would probably have resulted.

When fish are *inspected*, a general survey of those exposed for sale should be made. Any suspected fish should be opened and examined. The condition of the eyes and scales, together with the shape of the fish, should be noted. The gills should be firm and elastic and should be tested with the fingers if any doubt exists. If the fish appears to be in doubtful condition, it should be split and the backbone examined for signs of decomposition. If the bone is pink from the end of the tail towards the head, the fish should be condemned. The bone and blood should be tested by rubbing with the finger, since if the fish is fresh no taste or smell will adhere to the fingers. When stale, the abdominal cavity will be discoloured. Such fish should be split for examination of the backbone. The principal cause of fish condemnation is decay or putrefaction. Fish should be condemned for decay when rigor mortis has passed off, when the backbone shows evidence of any reddish-brown discoloration, or when the fish has a tainted or putrid smell. Condemnation is also indicated when the flesh strips cleanly from the bone, when the abdominal walls have a soft, pulpy, jelly-like appearance with discoloration and taint, when the gills are grey and slimy, or when the eyes are shrunken or grey. Most of the fish condemned for human consumption is so discarded because of decomposition. Less frequently, condemnation is based on the presence of diseased conditions or parasites. It is therefore most important that decay in fish should be speedily recognised.

When fish is inspected, only two qualities, i.e. good or bad, should be recognised. At some ports, fish of indifferent quality are often passed as suitable for immediate curing or salting and it would appear essential to standardise the methods of inspection in use at every port. The inspector should be careful to assure himself when called in to inspect fish, particularly in retail premises, that it is really unsound. Cases have occurred where the merchant has exerted subtle pressure to obtain from the inspector a certificate stating that unwanted fish is unfit for food. This practice is more likely to be prevalent when supplies are plentiful, but is rarely met with when fish is scarce.

The *keeping qualities* of fish vary, some types decomposing much more rapidly than others. The oily surface varieties, such as herrings or mackerel, should be eaten as quickly as possible after being caught, as they deteriorate rapidly. Cod, whiting and haddock will keep reasonably well, especially if stored under suitable conditions. The best keeping varieties are flat-fish, such as sole, plaice, turbot or brill. These fish improve in palatability if stored for a period. The keeping quality also depends upon the manner in which the fish have been caught, handled, packed and transported. As already stated, line-caught fish are generally in better condition than those caught in nets. Roughly-handled fish or fish which have been carelessly packed will decompose rapidly, as will fish which have not been properly gutted and which have portions of the internal organs or livers still adhering to the abdominal surfaces. Some fishermen bleed fish by making an incision behind the gills or above the tail. Fish treated in this manner are reported to keep better. Improper methods of packing in dirty containers are a frequent cause of staleness and decomposition. All containers used for packing fish should be carefully cleansed before use. Any fish placed in such containers should be tightly packed. Insufficient brine or ice used in packing will lead to rapid decomposition. Newly-spawned and diseased fish will decompose rapidly.

Diseased Conditions

In common with other forms of life, fish are affected with various diseases, of which the bacterial and parasitic types are the most significant. Of the *bacterial types*, fish pox, caused by *myxosporidia*, furunculosis due to infection by *B. salmonicidæ*, and salmon disease, caused by *B. salmonis pestis*, are all found in fresh-water fish. Tuberculosis is the only known disease affecting the salt-water variety. This latter disease is found in cod and turbot. The infected fish should be invariably condemned wherever bacterial infection is proved or suspected. Cancers and other varieties of tumours are found in all types of fish. As emaciation usually results, the affected fish should be condemned. *Mould or fungus growth*, due to *Saprolegnia ferox*, is mainly prevalent in fresh-water fish only. As the condition may spread from fish to fish, affected fish should be destroyed. Of the *parasitic diseases*, *Bothriocephalus latus*, a cystic form of tapeworm, affects many varieties of fish, including pike, halibut, turbot and the eel. As this parasite is transmissible to man when the fish is insufficiently cooked, infected fish should be condemned, as should haddocks affected with *Dokus acus*. In this condition the flesh of the affected fish emits a creosote-like odour. Halibut are affected with *epibdella*. The parasite is found attached to the skin ; if removed, the remainder of the fish can be used as food. *Echinorhyncus*, found in cod and salmon-trout, mainly affects the intestines. As these are not used for food, the fish may be passed as fit. *Fish lice* are frequently found attached to the skin of the flounder, while *lernians*, which live on the gills and skin, are often seen. The latter infestation usually causes emaciation. The affected fish should therefore be destroyed. *Tænia tetrarhyncus* is found in the cystic stage in whiting, haddock, halibut, cod and dogfish. Although it is harmless to man, the presence of this parasite in large numbers renders the fish unsaleable. *Filaria bicolor* is a threadlike worm found in an encysted state in cod, coal-fish, hake and pollock, young fish being chiefly affected. Cooking is said to destroy the parasite, which does not affect the consumer. It is easily observed when the flesh is cut, producing a brown or green discoloration. The fish is unmarketable when badly infested, the infested flesh turning brown during cooking and presenting an unpleasant appearance.

Preservation of Fish

Fish decomposes rapidly when taken from the water. The breakdown of the tissues is due both to autolysis and to the action of various types of bacteria, each type of activity producing changes of a putrefactive nature. When the fish dies, rigor mortis stiffens the flesh as the result of the coagulation of certain proteins. This condition is an indication of freshness. When rigor mortis has passed off, the enzymes of the body turn from digesting food to digesting the tissues with which they are in contact. The flesh then becomes soft and flabby, a strong fishy smell developing. These changes occur to some extent even when the fish is well iced. The action of the enzymes can only be checked by means of heat, which will destroy them, or by extreme cold, which retards their action. Fish are cold-blooded animals and do not possess any heat-regulating system. Because of this, they can be frozen alive in blocks of ice, so that they survive when the ice is thawed. Due to this fact, the enzymes present are capable of functioning at much lower temperatures than is the case with warm-blooded creatures. Autolysis is thus an extremely rapid process in the fish at normal atmospheric temperatures. The physical and chemical structure of the flesh is also different from that of animals. Bacteria are able to find their way from the slime of the skin into the blood by way of the gills, through the skin, which is not resistant to penetration as is the skin of mammals, and by way of the intestinal tract. The combined effect of autolysis and bacterial development not only causes flabbiness of the flesh but results in the exudation of moisture which consists of dissolved proteins, amino acids and minerals. Secondary changes follow, producing the typically offensive odours of decomposition.

Various methods of *refrigeration* are employed to maintain fish in good condition until they reach the consumer. *Ice* is extensively used for preservation purposes at sea, in boxes and in shops. This should only be regarded as a temporary means of preservation, as the quality of the product will be lowered after a short period of treatment by this means. Increasing distances between fishing grounds and the landing port have necessitated the employment of large quantities of ice, as trawlers often remain at sea for periods approaching one month before their catch can be disembarked. After gutting, the fish are packed in layers in the hold, a thick sprinkling of crushed ice being placed between each layer. The hold is filled until it is practically airtight in order that as low a temperature as possible can be maintained. Fish is transported from the ports to markets and retail premises in wooden boxes or barrels, packed in crushed ice. Many of these boxes are returned from inland towns to the ports in a filthy condition and require considerable labour if they are to be properly cleansed. Much more could be done by merchants to ensure that clean receptacles were returned to be re-filled. Freight charges are heavy, due to the weight of the container, the ice and the fish. The foul-smelling liquid which escapes from the containers pollutes the vehicles in which they are transported, together with the immediate surroundings of railway platforms and markets. Fish stored in ice can only be considered to remain really fresh for one week after they have been caught, and as " not stale " for a fortnight. The packaging of filleted fish is to be recommended, solid carbon dioxide being employed as a refrigerant. A low temperature is maintained during transport, although the quantity of carbon dioxide used is not sufficient to freeze the fish. If this method is employed, fish can be transported for long distances and maintained in really prime condition until sold. The handling of dripping and bulky containers is also avoided. Such fish are usually wrapped in grease-proof paper and packed in cardboard cartons.

Refrigeration is now widely employed. Many of the newer fishing vessels are fitted with refrigerating plants, the fish being gutted and frozen as soon as caught. Fish treated in this manner transport well over long distances. Brine is also used in place of water. This reduces the time required for freezing and produces less alteration in flavour and texture. Large fish are often frozen hard at very low temperatures. On shore, fish are sometimes frozen by placing the packages between refrigerated travelling belts or between refrigerated plates in a vertical press. Rapid freezing is generally employed, although pieces of fish treated in this manner must not be more than 3 inches in thickness. The rapid freezing of fish causes the gelatinous contents of the muscle cells to solidify as a frozen jelly, temperatures as low as −25° F. being used for this purpose. Slow freezing at temperatures between 32° F. and 23° F. damages the flesh, the extent of the damage being proportionate to the time of exposure. If freezing takes place slowly, the water content tends to separate and rupture the cell walls of the tissues so that, when thawing occurs, the juices and extractives are lost. A method of packaging in cartons or other containers has been developed, the fish being filleted, frozen in brine and placed in boxes composed of waxed cardboard. These are wrapped in greaseproof paper and stored in a refrigerator. This method of treatment will prevent any oxidation, dehydration or other form of deterioration due to exposure to the atmosphere, as will coating the frozen fish with a thin covering of ice. Before freezing takes place, fish are occasionally packaged and wrapped in moisture-proof cellophane. Fish treated in this manner should be stored in a refrigerator until delivered to the customer. Large amounts of cod fillets are packaged in this way and have been imported into this country in an attempt to overcome shortages during bad weather. Large quantities are also frozen at the ports in times of glut and are stored against scarcity. Freezing inhibits bacterial development but does not reduce the number of organisms present. When the product is thawed, rapid deterioration due to bacterial activity occurs. Some of these changes may even occur at storage temperatures well below freezing point. Changes in the flesh due to enzyme activity may also occur, even when the fish are stored at temperatures below zero. Changes are naturally slower under refrigerated conditions. Owing to the rapidity with which fish decomposes when removed from the refrigerator, some authorities recommend that it should be cooked in a frozen condition. It is an advantage, however, to cook fish as soon as thawing or defrosting have been completed. If this is not done the fish is likely to be unpalatable and tough. When thawed, frozen fish is usually dull and lacks the characteristic sheen. It tends to be soft and flabby, small particles of ice being visible in the flesh. Imported frozen fish will often exhibit a yellow discoloration near the skin and may possess a rank taste.

Drying is often used to preserve fish, especially on the Continent and in America although this practice appears to have ceased in Great Britain. The mosture content is lowered sufficiently by drying to inhibit bacterial growth, although it must be remembered that dried fish is not usually sterile. Fish treated in this way are beheaded, opened flat, eviscerated, scaled and cleaned. In some cases they are allowed to soak in brine for several hours. Large fish are often skinned and cut into small pieces. The fish are then placed in wooden troughs with alternate layers of salt. They remain in the trough for several days, after which they are turned over and left for a further period. The fish are afterwards left to dry on mats or stakes for several days, the period varying according to their size. Mechanical drying is practised in some continental countries. Cod, ling, hake, coal-fish and haddocks are dried by this means. Fatty fishes are not usually dried as difficulties are likely to be encountered with the fat, which hardens during the process owing to the absorption of oxygen. Only a small percentage of fish is treated in this way in this country, and this is mainly for export. The final product is not particularly appetising, takes some time to rehydrate and does not possess a pleasing appearance. It is none the less esteemed in countries which have large populations and where agricultural products are scarce.

Cured fish is dry and firm, yellowish in colour and is usually thickly encrusted with salt. The moisture content is reduced to about 45 per cent. while the salt content is increased to 22 per cent. It is sometimes cooked to sterilise and partly dehydrate the tissues before it is dried. A pink discoloration is occasionally found, this being due to the action of micrococci and to the organisms found in the sea salt used for treatment. This condition is usually more prevalent during summer than in winter. If discovered in this condition, dried fish should be condemned. This type of cured fish does not absorb moisture to any appreciable extent, but once the moisture content is increased favourable conditions for bacterial growth will be present. Deterioration may then quickly ensue. When in unsound condition, dried fish is moist and crumbly and emits an offensive odour. Lengthy storage makes the product tough and rubber-like, due to oxidation of the fat and denaturation of the proteins. During storage dried fish tends to rehydrate. For this reason it should be stored in airtight containers.

Large quantities of fish, particularly herrings, are treated by a process of *salting* prior to export. Fish are also salted to some extent before smoking or curing. As previously mentioned, this process is occasionally combined with drying to dehydrate the tissues. When fish are salted, water passes from the tissues by osmosis, salt taking its place. This dehydration and salt concentration inactivates the enzymes and inhibits bacterial growth. A 4 per cent. salt solution will retard decomposition ; a 20 per cent. solution will prevent this form of deterioration entirely. Herrings are often so packed for export. After they have been gutted and split, the herrings are mixed with salt and packed in barrels, backs downwards, as tightly as possible, care being taken to avoid injury to the fish. Salt is sprinkled between each layer. When the fish have settled, the barrels are filled with salt brine and sealed ready for transport. The presence of calcium or magnesium in the salt retards its penetration. Preservation is not then so thorough, as is evidenced by the increased quantities of amino-acids produced during storage. The osmotic effect exerted by the salt will draw sufficient water from the fish to form a pickling liquid which will cover them. Some small fish are salted without evisceration so that certain desired flavours may be produced. Generally, however, they are eviscerated, bled and thoroughly washed before salting. Careful evisceration is important. The more thoroughly this is done the less bacterial and autolytic decomposition is likely to result. Salting does not, however, prevent rancidity or oxidation of the fish oil present. Fatty or oily fish, such as herrings, sprats and mackerel, deteriorate in this manner to a much greater extent than do cod or haddock, which are less oily by nature. Fish so affected darken in colour, while rancid flavours and offensive odours develop. These changes may be retarded by brine storage under cool conditions.

Pickling is applied to certain types of fish: herrings, sprats, mackerel and some varieties of white-fleshed fish, particularly cod, being treated in this way. The fish are cleansed and washed and are then placed in brine and pickled for varying periods. They are then packed in watertight barrels for export and they can be stored for long periods.

Smoking is extensively employed as a means of preservation, and it is important that the fish should be fresh, otherwise a poor cure will result. Staleness may be disguised to some extent by heavy smoking but the condition of such fish is revealed by discoloration of the stomach cavity and along the backbone. Large quantities of smoked fish are prepared and eaten annually in this country, while a reasonable amount is exported. This method is not so important as canning or freezing. The process invariably dries the fish, since it is difficult to separate the smoke from the heat generated by the burning wood or other materials employed. As with meat products, a smoking salt is sometimes used for preservation. This imparts the required smoked taste but is not often employed for treating fish. Smoking invariably follows salting. Both processes dry the fish, while the action of the smoke deposits its constituents in the tissues and imparts the characteristic taste. Small fish are usually treated without evisceration. Larger fish are always carefully gutted and split. Two methods are employed. One of these, most often employed in Scotland, is known as the *low-temperature* method. This is carried out at 80° F., the process lasting for a period ranging from several hours to several weeks, according to the final condition required. With the *high-temperature process*, known as hot smoking, the fish are placed near the smoking fire. The treatment is completed within a few hours, the fish being partially or fully cooked during the process. The enzymes are destroyed if the temperature is excessive. The method of treatment varies according to the type of fish undergoing processing and the final result required. In smoke-houses the fires may either be built upon the floor or in special fire-boxes. Small logs of hard wood are ignited by means of shavings or chips. When these are burning, various types of non-resinous wood are added to produce smoke, the ideal wood producing adequate smoke without undue flames. Sawdust is frequently used in conjunction with other woods. Resinous wood is rarely employed, as it produces a poor flavour in the final product. Coke is also used for the treatment of some types of fish.

(1) *Bloaters.* In the production of bloaters, which are among the most important smoked products, herrings are rubbed with coarse salt to remove the slime and scales, after which they may be eviscerated but not split. The head is left intact. The fish are washed and allowed to soak in brine or are stored in salt for periods up to twenty-four hours. They are then threaded by the mouth and gills on sticks or rods, allowed to drain and dried in a curing house over a fire of wood chips or over coke braziers, ten to twelve hours being sufficient for the purpose. The common method of testing for fitness is to break and smell. If sound, bloaters are dry and crisp ; if stale, crispness is absent.

(2) *Findon Haddocks.* This type of smoked fish, which derives its name from Findon, in Aberdeenshire, are haddocks which have been beheaded, gutted, split and washed, care being taken to remove the black lining from the stomach cavity. They are then pickled in strong brine for two hours, allowed to drain and smoked for six to eight hours, softwood sawdust being used for this purpose. Peat is sometimes employed. The fish take on a light yellowish colour and require storage at low temperature to prevent spoilage. To test for freshness the fish should be incised at its thickest point near the bone and smelt. This incision does not spoil the market value of the fish. Unsoundness is denoted by stickiness along the bone and an offensive odour. Boxed smoked haddocks sometimes emit a disagreeable smell even when in sound condition. Other types of fish occasionally cured in a similar manner are small cod, sprats, pilchards and mackerel.

(3) *Smoked Fillets.* Haddocks, cod and other large fish, such as ling, are beheaded, skinned, gutted and washed, and scrubbed in clean fresh or salt water. They are then cut into pieces and pickled in brine for half an hour, after which they are dyed with some synthetic colouring agent, dried and smoked. The fillets are deep yellow in colour. If unsound, they will be moist, soft and crumbly and will emit a stale odour. Colouring by means of aniline dyes is not permitted by legislation. The use of such prohibited dyes may be detected by means of a few drops of sulphuric acid. If one of these dyes has been employed, a blue colour will appear when the acid is used.

(4) *Kippers.* Kippers are herrings which have been split, eviscerated and thoroughly washed, pickled for an hour in special coloured brine, allowed to drain and smoked in a kiln over smouldering wood chips and oak sawdust, peat or bark. They are an extremely popular food, 50 per cent. more kippers being eaten than fresh herrings. Herrings are sometimes boned before being kippered. Special varieties are sold attractively wrapped in cellophane. Normally they are packed in boxes. The flesh is usually soft and oily. A satisfactory test for soundness is to lift the backbone and smell underneath. If the herrings are not fresh when cured, the resulting kippers will soon become unsound and putrefy. Even under normal conditions well-cured kippers do not keep well, remaining sound for a few days only at ordinary temperatures. Stored at 30° F., they will keep sound for about one week. If not well cured, they will be unpalatable after two days.

(5) *Red Herrings.* This variety of cured herrings, which are thoroughly salted and smoked until dry and hard, are not now often seen in this country but are frequently prepared for export. They are sometimes used in the preparation of bloater paste. The fresh herrings are not gutted but are cured in salt and allowed to remain until required for smoking, this process usually lasting from one to two days, depending upon the weather and the size of the fish. In some cases, the herrings may remain in the salt for longer

periods. Because the salting process causes the fish to shrink, they are placed in a vat of clean, cold water for two to three days until they have resumed their normal size. They are then drained, threaded on rods through the gill slit and hung in the smokehouse, being treated until the required colour is obtained. The smoking process is occasionally carried out in the same smokehouse in which haddocks are being cured. When this is done, the herrings are placed near the roof and remain in the smoke for two to three weeks. They may, if desired, be treated separately on successive occasions, in which case they start at the base of the smokehouse and are moved upwards each day as fresh herrings are added. It is not advisable to fill the smokehouse immediately, as the air would become saturated with moisture, which would condense on the fish and favour spoilage. This intermittent procedure is repeated until the smokehouse is filled, when smoking may be continued for a further maximum period of three weeks. The resulting product is dry and firm. Red herrings will keep much longer than kippers, having a storage life of several months. Their salt content averages 16 per cent.

(6) *Smoked Salmon.* Salmon is quite often smoked, and the cured fish is looked upon as a delicacy.The fish is gutted, cleaned and filleted and then immersed in brine for eight to ten hours, afterwards being smoked for fifteen to thirty hours. It should be noted that, as the product is not cooked in any other way before it is consumed, great care must be taken to ensure that fish treated in this manner are perfectly fresh and sound, and free from decomposition, which is not inhibited by smoking. The final colour of the fish is a dull red.

Frying is a popular method of fish preservation. When treated in this manner, the keeping qualities of the fish are not comparable to those obtained when other methods of curing are employed. There is a substantial and increasing demand for fried fish, especially in the industrial areas. Large quantities of the cheaper kinds, which might otherwise be wasted, are utilised for this purpose. The fish are cleaned, filleted and occasionally skinned before cooking, although this is not invariably the custom. The portions are then dipped in flour batter and cooked in boiling fat. When fish treated in this manner are sold with chipped potatoes, they provide a cheap and nourishing meal. Various types of fat are employed for cooking. These include lard, beef dripping, peanut and cotton-seed oils, or a mixture thereof. Fried fish may be unsound due to staleness or to sour batter. To ascertain the state of the fish they should be broken and smelt. Nuisances may arise from the process of fish frying, due to burning of the cooking medium as a result of too high temperatures or to unsatisfactory cooking ranges which do not consume their own fumes.

Canning is a universal means of preservation, numerous varieties of fish being treated in this manner. The process depends for its preservative action upon the heat-treatment of the product in hermetically-sealed containers. Salted or smoked fish may be canned to increase the life of the contents and to add to their palatability. Some types of fish, such as salmon, hake, cod, crabs, lobsters, tuna fish and snoek, are canned in the ordinary way after being cut into portions. Others, such as herrings, sardines, mackerel, sprats, anchovies and brisling, are often preserved in vegetable oils. The methods of treatment vary according to the type of fish being handled. Usually the head, viscera, blood and large fins are removed. The fish is then washed, trimmed and packed into cans. This work can be carried out by hand, although machinery has been developed for the mechanical treatment of salmon and sardines. Many varieties of fish treated in this way are soaked in brine before canning takes place so that a desirable body and flavour can be obtained. Some are cooked, while others, e.g. sardines, are cooked and dried, before canning operations commence. The filled cans are placed in a steam chamber or exhauster for a short period and are hermetically sealed. The interior surfaces of the cans are often lacquered with enamel. This is particularly important if the product contains sulphides. The tops are crimped on to the can bodies, which are then rolled or double sealed over a suitable gasket to ensure their hermetic closure. Fish packs very solidly, so that heat penetration is slow. To ensure proper sterilisation of the contents, the cans are processed under steam pressure at temperatures between 230° F. and 240° F., the time of processing varying according to the contents and the size of the can. The methods employed in dealing with the main types of canned fish are as follows :—

(1) *Sardines.* The true sardine or young pilchard is a native of the seas surrounding the Spanish peninsula, large quantities being imported annually into this country from Portugal. Young herrings or sild are sometimes canned as sardines on the east and west coasts of the United States of America. The fish are beheaded and the entrails removed. They are then soaked in brine for one to two hours, after which they are trimmed and allowed to drain. The fish are graded, dried, placed on wire frames, lowered into boiling olive oil and cooked. When cooking is complete, they rise to the surface and are removed, either to drain naturally or to be dried in special heated chambers. In some cases the fish are cooked by steaming, this being the American practice. They are afterwards placed in the cans and covered either with hot olive oil (first grade), hot vegetable oil or tomato *purée* (second grade), the cans being capped and sealed. As the fish are packed hot, the cans do not need to be exhausted, although the sealed cans are processed in boiling water or in a retort for 120 minutes. After treatment, the cans are cooled, dried in sawdust and tested for leakages. A further treatment with sawdust is given before they are packed. Sardines may be smoked before they are canned. Herrings, pilchards, mackerel, sild and brisling are canned in a comparable manner. Anchovies are treated similarly but are usually filleted and packed as fillets.

(2) *Salmon.* Salmon canning is mainly undertaken on the west coast of Canada and the United States of America, although canned salmon is prepared both in Japan and Russia. Several varieties of salmon are used for canning, the sockeye salmon, which has a deep red flesh and high oil content, being most favoured, not only for its nutritional value but also for its attractiveness. The king salmon, which is the largest variety, also possesses a deep red flesh and is highly valued. These varieties are canned and sold as Grade 1 salmon. Another variety is the silver salmon, which possesses a pale pink flesh, as does the pink salmon. While the flesh possesses a pleasing flavour, lack of colour prevents these latter varieties attaining the popularity of the deep-red types. These pale types are canned as Grades 2 and 3 salmon, as is the flesh of the dog salmon, a product of Japan and eastern Russia. This latter fish is often preserved by salting or smoking, its flesh being soft and pale pink in colour.

Canning factories are situated as near the source of supply as is possible, so that the fish may be handled in a fresh condition. When caught, the fish are allowed to stand for varying periods according to species. A proportion of the moisture content will be evaporated during this period, after which they are washed to remove dirt and slime. The fish are cleaned of blood and scales, afterwards being beheaded. The viscera are removed, usually by mechanical means. The fish then pass to a machine which trims them into cutlets of the required size. The cans are filled, a ¼-ounce of salt being added to each 1 lb. can, after which they enter the steam exhaust box, where they remain for five minutes at temperatures in the neighbourhood of 98° F. to 100° F. The covers are placed on the cans while they are still hot so that a vacuum results after cooling. The cans are double-seamed, washed and processed for one and a half to two hours at temperatures between 242° F. to 248° F. They are afterwards washed and cooled rapidly to prevent softening of the contents. They are finally dipped in shellac, dried, labelled and packed. High temperatures and lengthy processing are required to soften the bones, which are rich in calcium and phosphates.

(3) *Crab.* Crabs are boiled and cooled in salt water. The shells are cracked and the flesh removed. Cans lined with parchment paper are filled with the white crab meat which is often dipped in a weak solution of citric or acetic acid to prevent discoloration. They are then exhausted prior to processing in boiling water or in a retort. The brown meat is either canned separately as crab paste or used as an ingredient of fish paste in jars. Lobsters, prawns, crayfish and shrimps are treated in a similar manner.

Potting is employed mainly for the preservation of shrimps and prawns. The fish are boiled in salt water and their skins peeled off, after which they are suitably seasoned with salt and pepper. They are finally placed in pots, which are heated to sterilisation temperature. When cooled, a layer of melted fat is run over the surface of the contents to protect them from atmosphere. Odour is the most accurate guide to unsoundness. The fat on the surface may crack and allow air to enter or may become rancid. Shrimps, prawns, mussels, cockles and herrings are often packed in sealed glass jars.

Manufacture into *fish paste* is another method of preservation widely practised. Large quantities of this commodity are sold annually. The paste is manufactured from a variety of fish, most often salmon, crab, lobster, sardines and anchovies, or a combination thereof, and the name of the paste should give a true indication of the fish incorporated in the substance. The fish to be used for this purpose are cooked, mixed with edible fat and cereal filling materials, seasoned and flavoured and coloured, minced to a fine paste and packed in glass jars of various sizes, which are sealed and sterilised. Fish paste must contain not less than 70 per cent. of fish and may contain a cereal or other type of binding material. When processed fish is used, the weight should be the net weight of the raw fish after all waste has been eliminated. Where canned fish is used for the manufacture of fish paste, the weight should not include any brine or oil. *Fish cakes* are often manufactured from cooked fish, potatoes and other filling materials ; such articles should possess a fish content of not less than 35 per cent. by weight.

While its manufacture is not strictly a means of preservation, *fish oil* forms a valuable product, largely used for medicinal purposes. Cod and halibut livers are extensively used for the manufacture of oil. The livers are removed from the fish as soon as they have been caught. Formerly the livers were allowed to decompose, as the bursting of the liver cells freed the oil, although the final product possessed a disagreeable taste and an offensive odour. The livers are now either cold-stored until landed to inhibit bacterial or enzymic action or processed at sea. The oil is separated from the livers by means of steam, either vacuum pans or steam-jacketed kettles being used. Vacuum processing yields a better coloured and more finely flavoured product owing to the lower temperatures which can be employed. After heating, the oil is cooled, usually to temperatures below 32° F. This allows the stearin to solidify and facilitates separation from the oil by pressure filters. The oil is then refined, being treated first with caustic soda solution, which unites with the free fatty acids to form soap. Being soluble in water, this is washed away. A dilute solution of sulphuric acid is next employed to neutralise any traces of remaining alkali. The oil is then filtered through Fuller's earth for bleaching purposes. Cod-liver oil, which is readily absorbed by the body, contains both vitamins A and D in considerable quantities. These oils are valuable as foods in the treatment of wasting diseases such as tuberculosis, and as preventive and curative agents in the case of rickets, especially in children. Halibut oil is considerably richer in vitamins A and D than is the variety extracted from cod livers and is finding a ready sale in capsule form. Cod-liver oil is either sold in its natural refined state or mixed with other chemicals to form an emulsion.

All fish scheduled for preservation should be fresh, properly cleansed and gutted and effectively processed. The fish should be examined before treatment and after preservation. Methods of inspecting canned foods, including fish, are detailed in Chapter XXV. When cured fish decomposes, a most unpleasant odour is emitted. If stored under damp conditions black spots, due to fish mites, may appear upon the external surfaces. Dried salted cod occasionally exhibits a rust-red appearance. This is produced by the activities of a micrococcus. Although no known disease can be attributed to these conditions, the affected fish should be destroyed as unfit for human consumption.

The *premises* and *methods* of handling fish during preservation are of particular importance, as the slime which covers the fish when taken from the water harbours many bacteria. This slime will contaminate all fish-handling equipment. Sanitary methods of treatment must therefore be strictly applied. Chlorinated sea water should be readily available for cleansing purposes, while any brine solutions in which fish are immersed should be maintained in a chlorinated condition. The salt employed for making up brine solutions or for the dry-salting of fish should be perfectly pure ; the brining process should be carried out at a temperature of 50° F. or less. The preliminary drying of fish prior to smoking should be speedily completed and should be assisted by the rapid circulation of warmed air. All internal surfaces of the plant employed should be provided with a smooth finish, be non-porous and easily cleansed. The walls should preferably be tiled to assist cleansing operations. The floors should be either tiled or constructed of concrete, with suitable falls for proper drainage. Walls, floors and ceilings should be rat-proof. All metal parts should be constructed of stainless steel to obviate corrosion. The operators, who should receive frequent medical examinations, with the necessary laboratory tests, should cleanse their hands at frequent intervals in chlorinated water. The entire plant should be flushed regularly during the day and should be well scrubbed down when processing has been completed. Adequate facilities for the cleansing and sterilisation of all equipment should be available. Gutting and cleansing of fish should be carried out under a constant flow of water.

Nutritive Value

The *chemical composition* of fish varies to an appreciable extent. Sardines, salmon, mackerel and herrings, in that order, contain the greatest percentages of fat, while cod and haddock contain the lowest percentages. The quantity of fat present varies according to the season although the fatty varieties of fish may contain as much as 20 per cent. Sardines and salmon are richest in protein, although most fish possess fair proportions of this substance. Generally speaking, fish are a valuable source of protein, containing between 15 and 18 per cent., although the quantity available is lower than that in meat. The protein content of dried fish is markedly increased owing to removal of the moisture content during processing. The ash content is usually higher than that of carcass meat, and is highest in salt-water fish, due to their saline environment. The moisture content of fish is considerably higher than that of meat. Shell-fish contain a small percentage of carbohydrates in the form of glycogen. Of all fish, sardines have the greatest food value. Oysters contain a small amount of iodine, while the value of this shell-fish in the treatment of anæmia is believed to be due to the presence of certain iron compounds. As already indicated, fish oils have attained prominence because of their vitamin content and medicinal properties. The oils of non-fatty fish are present almost entirely in the liver. Because of their high market value, great care is now exercised in gathering, extracting, purifying and storing such oils.

Lean fish and oysters are as digestible as lean beef ; oily fish, crab and lobster have an equivalent digestibility to fat meat, the fat being approximately as digestible as any type of animal fat. Fish proteins have a reasonably high nutritive value, although not equalling those found in liver, kidney or carcass meat. In suitable quantities they are sufficient for growth promotion. The proteins of cod, herrings and salmon are held by some authorities to be equivalent to those of beef. Generally speaking, fish protein is equal to most meat proteins and vastly superior to the majority of vegetable proteins.

Fat fish contains appreciable quantities of vitamins A and B. As already mentioned, fish livers are rich sources of vitamins A and D while the roes are good sources of protein and water-soluble vitamins. Vitamin C is reported to be abundant in the roes of fresh-water fish, while canned salmon of certain types contains vitamin G. Vitamin D is also present in canned salmon. As this type of fish contains an appreciable amount of oil, particularly in the best grades, its nutritive value is high. Herrings, sardines and shrimps contain vitamin D. Oysters are good sources of vitamins A, B_1 and G. The vitamin A content of these shell-fish is decreased slightly when they are cooked, although vitamin B_1 is not appreciably affected by this process. Oysters and other molluscs contain reasonable amounts of easily digested carbohydrate in the form of glycogen, while the oyster is only excelled by liver in the quantities of iron and copper which it contains. Salt-water fish contain larger amounts of iodine than do fresh-water varieties. Because of this, sea food is extremely valuable where the normal ingestion of iodine is low and where goitre is prevalent. Other minerals, such as calcium, phosphorus, manganese, copper and iron, are present in fish in relatively large quantities. *Fish flour*, a dehydrated product manufactured from edible fish waste, is said to possess nutritional value. It contains large quantities of mineral matter, particularly calcium and phosphorus. White-fleshed fish is nutritious and easily digested ; digestion of the fatty types of fish presents greater difficulty.

Epidemiology

The diseases caused by the consumption of fish other than shell-fish, dealt with in the following chapter, are rare in this country. This is probably due to the fact that fish is mostly eaten when cooked. The interior of fish is usually sterile, although numerous organisms are present on the skin, particularly in the slime which adheres to it, even when the fish has been freshly caught. The skin of the healthy fish is covered with a thin mucous layer, which increases after death. This layer is composed of nitrogenous substances which assist the numerous types of organisms to develop. The slime is the reason for the dirty conditions which often exist in retail shops and in fish-preparing premises. Bacteria on or near the gills are an important source of infection. These produce spoilage and a rapid increase in bacterial decomposition. Coliform organisms are rarely present in deep-sea fish but are often found on fish taken from the polluted waters of estuaries. They can also be present as the result of gross contamination in handling and distribution. There are no bacterial standards for fish. The best means of preventing bacterial growth are : (*a*) bleeding the fish immediately after it has been caught, (*b*) speedy evisceration of the intestines and stomach, and (*c*) careful washing in chlorinated sea water or brine.

Symptoms of fish poisoning other than those caused by shell-fish fall into two categories : (1) gastro-intestinal disturbances accompanied by prostration and the appearance of a rash, and (2) severe nervous prostration and convulsions. Several cases of fish poisoning have been attributed to organisms similar to *Clostridium botulinum*, although salmonella poisoning is rare. Typhoid fever has been produced by uncooked fish. Some species are only poisonous when caught in certain localities or at spawning time ; alternatively, the ill-effects may be due to the consumption by fish of certain types of food. The roes of pike, sturgeon, carp, bream and turbot will produce violent intestinal disturbances if eaten during the breeding season. Abraham, in 1906, reported twenty-eight cases of fish poisoning due to pike, organisms of the aertrycke type being isolated. Fish-roe poisoning is said to be common in Russia. Cases of intoxication from infected fish have also been reported from that country. The products of decomposition are extremely toxic and produce an illness which closely resembles botulism. Salting does not destroy the toxins, although the putrefying organisms may be destroyed by this process. If the salted fish is insufficiently cooked a severe form of poisoning may ensue.

Some varieties of fish should be eaten as soon as caught if harm is to be avoided. Mackerel has a poor reputation in this respect, due to the rapidity with which it decomposes. Mackerel should therefore be eaten as soon as possible after it has been caught. If consumed out of season, poisoning may result. Some individuals exhibit an allergy to herrings and mackerel, becoming ill after eating them even when the fish are in a fresh, sound condition. The symptoms are vomiting, diarrhœa and prostration, often accompanied by urticaria. Canned fish affects some individuals in a similar manner. Cases of food poisoning due to smoked white fish have been reported from a variety of sources.

Infestation with the cystic form of the tapeworm, *Bothriocephalus latus*, which may infect man following the consumption of infested fish, particularly when eaten raw or in an under-cooked condition, has been reported. The symptoms range from simple gastric or nervous disorders to severe anæmia, weakness and cardiac disturbances. These symptoms disappear if the parasites are cleared from the intestines. Generally speaking, food poisoning due to the consumption of either fresh or salt-water fish does not form a serious problem provided the fish is eaten in a fresh condition. The principal danger lies in the non-detection of incipient decomposition and in the possible lack of care in the preparation of preserved varieties.

Fish Handling

The handling of fish in retail premises and in markets leaves much to be desired and a considerable improvement in the methods employed is overdue. Fish appears to be regarded as a commodity rather than a foodstuff and whereas in the case of other foods some attempt is made at hygienic handling, there appears to be a widespread failure to appreciate the fact that fish should be handled as carefully as other food materials. Fresh fish does not smell fishy. Any strong odour, therefore, is a clear indication of the presence of decomposition either in the fish or in the fish products. Fish dealers seem to believe that all contamination can be quickly washed away by the use of copious supplies of water. In practice, the methods of handling should be such as will prevent any chance of contamination or pollution, both of which may result in rapid decomposition. The sanitary conditions under which fish is handled are just as important as in the case of other foodstuffs and require the same constant consideration. Fish should invariably be maintained at a temperature below 50° F. during all stages of transportation, storage and retail sale. Intensive education of consumers is also necessary in order that they may more fully realise the perishable nature of fish and the disease hazards which may ensue.

All equipment should be manufactured from materials impervious to the absorption of fish-polluted liquids. For this reason, wooden slabs for the display or cutting of fish, often still to be seen in shops and public markets, should be prohibited, as should the hawking of fish from open carts and handbarrows which have not been provided with impervious surfaces. All utensils, benches, tables, receptacles and knives should be thoroughly cleansed daily. Hard impervious materials, free from cracks and crevices, e.g. stainless steel, should be used for benches, receptacles and tables. Wooden fish-boxes and barrels are almost universally employed for transportation purposes. These are never really clean, even when the most painstaking methods have been employed. This is evidenced by the strong fishy smells which emanate from them. An adequate substitute should be found, such as aluminium alloy. The walls and floors of fish-retailing premises and markets should be maintained in a thoroughly clean condition, floors being adequately washed with chlorinated water and suitably drained. Employees should be healthy and should frequently wash their hands in chlorinated water. An adequate supply of hot and cold water should be available for this purpose. All refuse should be collected into covered metal receptacles. These should always be kept covered except when they are to receive further additions to their contents. Utensils should never be placed on the floor, and should always be cleansed and sterilised immediately after use. On the whole, it may be stated that the fish industry has not made the same advances in the field of hygiene as have been evidenced in other branches of the food trade.

CHAPTER X

SHELL-FISH

SHELL-FISH, of which there is a plentiful supply around our coasts, are popular with many people. For this reason, increasing quantities have to be imported annually from abroad to supply the demands of the consuming public. Shell-fish can be divided into two distinct classes :—

(1) *Molluscs.* These have soft bodies, protected by a hard shell. They include oysters, mussels and cockles.

(2) *Crustaceans.* In this type the body is encased in a hard close-fitting shell. They possess legs and can travel reasonable distances. The flesh is firmer than that of molluscs. Examples of this variety are lobsters, crabs and prawns.

Molluscs

The oyster is the most widely consumed of all the molluscs. Many of this type of shell-fish are identified as regards consumption with particular parts of the country, an instance being the consumption of mussels in our northern industrial areas, winkles and whelks taking their place as a favourite London dish.

Oysters

The oyster has a tender delicate-flavoured flesh, protected by a strong shell. It is found distributed in most temperate waters. In some areas the demand for oysters has so depleted the breeding grounds that this bivalve is now almost non-existent. Pollution by sewage has also resulted in the closure of many natural oyster beds. The result has been that oysters are now almost invariably cultivated in certain selected sites.

The *life cycle* of the oyster is of considerable interest. Spawn is discharged by the adult female mollusc during a period of several months when suitable water temperatures, in the region of 68° F. to 70° F., are reached. The small larvæ, being unattached and free swimming, are distributed by the action of the tides. Eventually they settle on the sea bed from low-tide mark to a depth of 30 feet or more, becoming attached to some solid object. In some areas old oyster shells are laid on the sea bed to form a suitable base for the attachment of the young molluscs. Under favourable conditions, oysters cannot be harvested unless a period of between four to six years has elapsed since birth. Layings are usually made in estuaries and on rocks near the shore. Oysters develop best in waters where the salinity is low, as in river mouths. Here the water is a mixture of fresh and salt and, if the bottom is hard, conditions are extremely favourable. A salinity of between 1 and 2 per cent. is most to be desired. Their food consists of microscopic plants and other organic matter in suspension in the water. They thrive best where the tide or current is strong, as all their food must be carried to them by the movement of the water. Starfish are notorious enemies of oysters, beds never being laid where it is known these latter fish are present. Many oyster waters are leased by companies or individuals, while some are publicly owned.

The harvesting of oysters is carried out by means of dredges. A dredge consists of an iron framework to which is attached a blade, with or without teeth, and a bag. This apparatus is used as a scoop by men standing in boats. At it travels over the sea bed the dredge gathers up the shell-fish by the forward movement of the boat. Power dredges are used in the deeper waters. Immature shell-fish collected are relaid in special beds according to their size and are gathered when known to have reached maturity. The mature specimens are brought ashore and packed in ice for transportation. If oysters are not properly handled after being brought to the surface, spoilage may be rapid. Ice used for packing should not be allowed to come into contact directly with the shell-fish. This prevents dilution with water and reduces the chances of bacterial contamination.

In some countries oysters are packed without their shells. This simplifies transport by lessening the weight to be carried. The shells are opened by the insertion of a sharp knife, which cuts the adductor muscle, the meat being cut free from the lower shell and dropped into a container which usually contains a small quantity of water. The oysters are then washed in tanks of salt water agitated by means of compressed air, the delicate meat being thus uninjured. This process must not be continued for longer than three minutes, otherwise the shell-fish will absorb an excessive quantity of water. The oysters are drained, packed in cans with tight-fitting covers and kept well iced. Oysters treated in this way usually show a higher bacterial content owing to contamination during handling and contact with equipment. Bacterial development may be rapid under unfavourable conditions.

Large quantities of oysters are *canned* for future use, particularly abroad. After they have been gathered and washed, they are placed in horizontal steaming chests under several pounds steam pressure. This process kills the oyster and allows the shell to open, the liquor draining away. The shrivelled meat is cut out from the shell and placed in cans which are filled with brine. The meat absorbs a certain percentage of water, which to some extent restores to the oysters a more normal appearance. The cans are hermetically sealed and sterilised in autoclaves under steam pressure at 240° F. The handling of oysters after harvesting is particularly important. Sanitary handling should be rigidly observed. Oysters are commonly eaten raw so that any contamination must be strictly avoided. They should be eaten immediately after they have been opened.

Oysters, which are rarely found in a diseased condition, should be grown in waters free from any risk of sewage pollution, as they are extremely liable to contamination from impure water. Legislative action can be taken against the owners or lessees of infected layings to protect the public by prohibiting the sale of infected shell-fish. If oysters which are in an infected area are removed to clean water, they can cleanse themselves by discharging the infecting bacteria in from ten to fourteen days, provided the temperature and salinity of the water are suitable. The salinity of the water should be comparable to that of the original water from which the oysters were obtained. It is usual, therefore, to relay oysters in shallow concrete tanks containing chlorinated sea water. If the chlorine content of the water is too high the oysters will not open their shells and feed. Cleansing will not take place under such conditions. The original chlorine content of the water may be used up by discharged intestinal contents and organic matter, so that a second dosage of chlorine may be required. Twenty-four hours' immersion is usually sufficient. In this country the shell-fish are held in sea water which has been previously chlorinated to destroy any fæcal organisms which may be present. The water used contains no free chlorine during the holding treatment. The process of cleansing must therefore be carried out for longer periods. Cleansing frees the oysters from any contaminating materials, provides storage until they are required for use and improves their final quality.

Oysters have creamy-white bodies enclosed in two hard ovoid shells, held together by strong adductor muscles. " Native " oysters is the term applied to those obtained from districts situated off the mouth of the Thames and adjoining rivers, particularly in the neighbourhood of Colchester and Whitstable. Such oysters are thin-shelled and small as opposed to the deep-sea variety, which are much larger and possess thick rough shells. Natives are in prime condition when between four and six years old. When fresh, the shells of oysters are tightly closed ; if open, they should close quickly when tapped. Unsoundness is denoted by an offensive odour and by gaping shells which do not close when tapped and give out a hollow ring. Oysters with gaping shells are either moribund or dead and are unfit for human consumption. Slightly-open shells denote loss of freshness. Such oysters should be viewed with suspicion. The close seasons for English native oysters and for deep-sea oysters is set out on p. 110. Foreign oysters may be sold throughout the year.

Oyster dealers often find it necessary to carry large stocks in order to fulfil orders which, owing to weather conditions at the fishing grounds, they would otherwise be unable to meet. When shipped directly from the water, these shell-fish possess a much better appearance than would be the case if they had been stored in a dry condition. For this reason it is usual to store oysters under water, this practice being termed " floating." If the water contains less salt than the original liquid in which the oysters were grown, floating increases their size. Unscrupulous dealers have employed this process to impart a deceptive appearance of quality. If water is used for floating purposes, it should be pure in order to minimise the risk of contamination.

Mussels

Mussels are bivalves measuring between 2 and 3 inches in length. The flesh, soft and red or yellowish-red in colour, is enclosed between two oval shells, which are blue-black externally and glistening white inside. These shell-fish are plentiful around the coasts of Britain and Holland, being imported from the latter country in large quantities. They are found on the sea bottom and in clusters on rocks, being particularly numerous in estuaries, where the water may be often grossly polluted. They are harvested by means of rakes and dredges. A close season is in force, mussel harvesting being prohibited between May 1st and August 30th. They are at their best during the later months of the year. Mussels are especially prone to sewage pollution. If placed in clean water they can cleanse themselves in a few days. At the seaside towns of Conway and Lytham, where mussels are plentiful, cleansing stations have been provided and deal with shell-fish gathered from over a wide area. The molluscs are given a succession of baths in sterile water, during which they purify themselves by discharging their bacterial content. A final bath in chlorinated water is given to sterilise the outside of the shells.

Mussels spoil rapidly when removed from water. This renders their transport for long distances impossible. When they are in a sound and fresh condition, mussels are usually closed and are exceedingly difficult to open. Stale or dead mussels gape, ring hollowly when unsound, are dull in colour and smell offensively. They are usually packed in canvas bags. Mussels are generally boiled before being eaten. As a means of preservation, they may be pickled and sold in glass jars or sterilised by canning. When treated in this manner, they do not shrivel as do oysters but retain their attractive appearance and pleasing flavour.

Cockles

Cockles are heart-shaped molluscs with two ribbed shells of equal size and thickness. They are to be found in estuaries and in sandy bays near the low-water mark, and possess a " foot " which enables them to burrow into the sand or mud. They are never out of season, but are in optimum condition during the latter half of the year. They are usually boiled before use and are apt to contain a certain quantity of sand. Large quantities are pickled and sold in glass jars, suitably sealed. When in fresh condition, cockles are usually closed. Like mussels, they are difficult to open. If the shells are open they will close if the fish is handled or the shell tapped. Unsoundness is denoted by an offensive odour, dull colour, and gaping shell, which will not close when the fish is dying or dead. When stale, cockles become rapidly offensive.

Escallops

These are species of mollusc which are plentiful around the shores of the British Isles. As they inhabit deep water they are not especially liable to contamination. They are free-swimming and are caught by means of drag-nets drawn over the sea bottom. Escallops possess two ribbed fan-shaped shells, provided with a hinge at the narrow end, one shell being more arched than the other. The shells are brownish-pink in colour externally, and pearly-white shading to pink on their internal surfaces. They are large, being between 4 and 5 inches across. The flesh has the appearance of a poached egg, the roundish white mass having an orange foot encircling it. Escallops are in season throughout the year, although their condition is best during cold weather. Their meat is sometimes soaked in water to increase their size. The shells may gape even when the fish is alive, but if the beard surrounding the body is touched the fish will move if fresh. Staleness and decomposition can readily be detected by smelling. Escallops are always cooked before being eaten.

Periwinkles

The periwinkle has a single shell, which is whorled and is somewhat similar to that of the snail. It is provided with a circular opening through which a " foot " emerges to provide means of locomotion. Periwinkles, or winkles as they are commonly termed, are numerous around the coasts of these islands. Large quantities are also imported from Holland. Like escallops, they are in season throughout the year but are in the best condition during the colder months of autumn and winter. When in sound condition, the " foot " is prominent and is not shrunken. Staleness produces an offensive odour. Normally a handful of periwinkles is tested for smell. The entire bag should be condemned if any evidence of staleness exists, as the juices from the stale molluscs will quickly contaminate the remainder. If the fish is fresh the meat should not break when removed from the shell. Periwinkles are always boiled before being eaten.

Whelks

These are single-shelled molluscs, the large snail-like shells being whorled and ridged and ending in a point. A large opening is provided in the shell, through which the " foot " protrudes. Although in season throughout the year, condition is best during the spring. Whelks are found in large quantities all around our shores. They are boiled before being eaten. When decomposing, whelks are clammy. When removed from their shells in this state, they smell most offensively.

Crustaceans

The crab is the most important fish of this type, although lobsters and crayfish are almost equally popular.

Crabs

The flesh of the crab finds a ready sale. Crabs are greenish in colour when caught, turning reddish-brown when boiled. They are plentiful all round our coasts and are caught in pots and by means of lines or dredges. They are killed prior to boiling by piercing between the eyes, otherwise the large claws will be cast. The male crab may be identified by the small apron, the name given to the armour-plated flap on the underside between the legs, and by the large claws. The female has smaller claws and a larger apron. The minimum size of crab allowed to be sold must be $4\frac{1}{4}$ inches across the broadest part of the back. Crabs are in season throughout the year but are in the best condition from April to July. The head and thorax are united to form a short squat body, enclosed in a hard limy shell. The abdomen is curved under the thorax. The crab possesses large claws and four pairs of legs. The shell is cast from time to time as the crustacean grows. When it is without a shell or during the casting period the fish is known as a " soft-shelled " crab. Although soft-shelled crabs cannot legally be sold in many countries, they are greatly appreciated by many people. Crabs may be packed in barrels or boxes and shipped in live condition for short distances. If longer transport is necessary, they are boiled and packed in ice. Unsoundness is denoted by the smell emitted when the apron is opened, by the odour from the joints of the claws and by general limpness of the body. A faded appearance indicates staleness. Crabs should not be wet or sticky under the large claws. Lightweight crabs should be condemned.

While many crabs are transported whole, the trade in dressed crabs or in crab meat for restaurant use is slowly growing. In such instances the meat is separated from the shell either at the site of boiling or on the premises of the retailer. The shells are usually cleansed to hold the crab meat during sale. The crabs are cooked and placed on tables, where they are cooled and trimmed. The shells are broken open and the meat removed by hand. The meat from the body and the claws of the crab is mainly white, although a proportion of brown meat is also present. This latter is often used for the manufacture of fish paste and is strongly flavoured. It can be well diluted by means of filling materials and still retain its characteristic flavour. The meat is either washed and seasoned and placed in the shell ready for sale or refrigerated and packed in cartons.

Much of the crab meat produced abroad is canned, the meat being removed from the shell as set out above and placed by hand into cans lined with parchment or greaseproof paper. The containers are closed and sealed, being afterwards processed under steam pressure. Large quantities of canned crab are imported annually into this country. The cans are usually double-lacquered since, owing to the development of acidity, the meat may become blackened or discoloured following the formation of iron sulphide after canning has taken place. Low acidity prevents this defect. Blue, grey or black discolorations may also develop within a few days or weeks following canning. This is probably due to a colour reaction between the copper and ammonia liberated from the crab tissues when heat is applied. Dipping in aqueous solution of salts of aluminium prior to processing is said to prevent this defect. Crab meat occasionally contains small solid particles which might be mistaken for glass. They are, in fact, composed of magnesium ammonium phosphate crystals, which may be present in the flesh of all crustaceans. The particles are harmless to the consumer. As in the case of lobsters and crayfish, canned crab meat may contain white deposits. These deposits are similar in appearance to moulds and are deposits of tyrosine.

Lobsters

The lobster group comprises lobster, crayfish, prawns and shrimps. These are long-tailed crustaceans with multi-jointed bodies and ten legs, two of which form claws or pincers which are unequal in size. The remaining four pairs of legs are present under a fan-shaped tail. The lobster has a hard shell which is blue-black in colour when the crustacean is alive, turning bright red on boiling. The male fish is readily recognised by the strong swimlets—the first pair of feelers, situated at the junction of the tail and the body—and by its narrow back. If lobsters are less than 8 inches in length from the tip of the beak to the end of the tail it is illegal to offer them for sale. They are in prime condition during the summer months and are caught all round the coasts of this country. As they cast their shells in a similar manner to crabs during growth, they are not allowed to be sold in a " soft-shelled " state. Lobsters are generally caught in pots, which are basket-like contraptions. The lobster is able to enter the pot at the top in search of food but, once in, is unable to find a way out. These fish vary in size, the best table lobsters weighing some 2 lb. each. When freshly caught, the lobster's claws retain their muscular action, which can be elicited by pressure applied to the eyes. If this reaction is absent the lobster is not fresh. Unsoundness may be denoted by the behaviour of the tail. If the lobster is in fresh condition the tail will quickly resume its original position when pulled back. There should be no sign of wetness or stickiness under the large claws. The posterior aspect of the tail should also be examined for discoloration.

Lobsters are usually forwarded to market in live condition and are boiled by the retailer, being plunged into boiling salt water, where they remain for approximately twenty minutes. Large quantities of canned lobster meat are imported annually from abroad. The method of treatment is similar to that set out for crab meat on p. 128.

Crayfish

This crustacean has the appearance of a miniature lobster but is an inhabitant of fresh water. Its antennæ are longer than those of the lobster, while its claws are more equal in size. English crayfish are greyish in colour when alive, assuming a deep reddish-pink colour after boiling. When alive, Norwegian crayfish are reddish-pink in colour. Crayfish are cooked in a similar manner to lobsters and are usually split in half for sale. Large quantities of imported canned crayfish meat are sold annually in this country.

Prawns

Prawns resemble miniature lobsters. They have small pincers and a long serrated beak with protruding horns, forming part of the snout. When alive, they are grey in colour with red markings and are occasionally semi-transparent. They turn bright red on boiling. Large quantities are caught off the British coasts in small-meshed trawl nets. Prawns vary in length from 3 to 5 inches, being in optimum condition during the summer months. They are not usually transported alive as they do not carry well. They are cooked by plunging into boiling salt water, where they remain for approximately eight minutes. When in sound condition they should have clear, prominent eyes, be crisp to the touch and emit a pleasant odour. Their tails should be turned inwards and should be stiff. When soft, heated or sticky, prawns are unsound. Prawns are also imported from abroad and are sold in cans or in sealed glass jars. Signs of decomposition in the raw prawn are readily detected ; when canned, decomposition is only detectable if the condition was advanced before canning took place.

Shrimps

Shrimps closely resemble prawns but are smaller and do not exhibit horns projecting from the snout. Two varieties of shrimps are marketed, the pink variety, which has red and white rings on the feelers and is found in deep waters, and the brown type, plentiful in the sandy estuaries round our coasts. Large quantities of shrimps are imported annually from the Continent. They are caught with fine-meshed trawl nets and are cooked in boiling salt water for periods ranging from five to eight minutes. During cooking they become brownish-pink in colour. After cooking they are transported to market in bags or hampers. Shrimps are in season throughout the year. When stale, the tail is inelastic and the body limp. In this state they emit an objectionable ammoniacal odour. The remaining symptoms of good quality or of staleness are similar to those set out in the case of prawns (see above).

On the Lancashire coast an extensive trade in picked shrimps is carried on, the shells of the boiled shrimps being removed while hot, usually by girls who display surprising speed and dexterity in their work. The fact that the work is, in many cases, carried out in domestic premises should not be overlooked in considering the hygienic handling of shrimps. Large quantities are potted or cartoned, a layer of fat being placed over the shrimps in the containers to exclude air. In the case of cartons press-on lids of the same material are used as closures. Shrimps are also imported in canned form from abroad. Shrimps should be picked within thirty minutes of death so that the intestinal tract can be removed with the head. If this period is exceed the intestinal tract may remain with the meat when the head is removed. The flesh is washed and blanched in hot brine. This changes the white colour of the meat to pink. The shrimps are then spread on trays to cool.

Premises

Premises used for the boiling and preparation of shell-fish should be entirely suitable for the purpose. In the past, numerous sanitary problems have resulted from the unsatisfactory conditions under which the work has been carried out. Many plants are located in insanitary surroundings, the meat being exposed to various forms of contamination while, as previously mentioned, handling in domestic premises is open to suspicion. Drainage may be unsatisfactory, while the operations may be open to pollution by flies and to offensive odours. It should always be remembered that shell-fish, particularly crabs, lobsters and the like, are rarely cooked after purchase, being presumably ready for the table when sold. It is also a fact that the workers often fail to appreciate the vital importance of correct sanitary measures. Buildings should be well lighted and ventilated, be vermin-proof and easily cleansed. Pans, knives and other utensils should be cleansed and sterilised immediately after use ; tables and premises should be washed and swilled down when the day's operations are over. Adequate lavatory facilities should be available. These should be provided with copious supplies of hot and cold water together with soap and towels. Employees should be required to wash their hands frequently. They should be healthy and should be medically examined at suitable intervals. These requirements do no more than satisfy the hygienic standards which any food-producing premises or personnel should be required to attain.

Nutritive Value

The chemical composition and nutritive value of shell-fish have already been discussed in Chapter IX, pp. 121 to 122.

Epidemiology

Shell-fish intended for human consumption should be obtained from clean layings, beds or stores. The possibility of sewage pollution must be especially watched. Outbreaks of typhoid fever and of bacterial food poisoning generally have frequently been reported due to the consumption of infected shell-fish, mainly molluscs.

Oysters have been responsible for *typhoid fever*. A notable outbreak was reported from Winchester and Southampton in 1902. In Southampton fifty-four persons suffered, fifty-two persons in Winchester being similarly affected. All had attended two banquets and had eaten oysters obtained from the same source. It was found that the oysters had been collected from ponds at Emsworth and that sewage from houses in which cases of typhoid fever had occurred was being discharged into the sea closely adjoining the ponds. These latter were flooded with sea-water at high tide. The oysters were apparently infected with contaminated sewage brought in by the tide. Polluted oysters were the cause of a typhoid outbreak in the United States of America in 1894, twenty-five cases being notified, with four deaths. Serious outbreaks of the same disease, due to the consumption of oysters, occurred in Chicago, New York and Washington during 1924, in which 1,500 cases were notified, with 150 deaths. Other cities were also affected. Before use the oysters had been stored in ponds presumably polluted by excremental discharges from passing boats. Cases of *salmonella poisoning* due to the consumption of fried oysters have been reported from America. Fresh oysters have also been responsible for cases of typhoid and paratyphoid fever and cholera. Several outbreaks of *botulism* have been reported following the consumption of canned oysters. When oysters become infected with the causative organisms of typhoid and paratyphoid fever, the bacilli do not multiply but will die after varying periods. Oysters are usually examined for coliform contamination, this providing a useful index to the presence of pathogenic organisms, especially those arising from sewage pollution. In addition to being present in sewage, coliform bacilli are found in the waters of our estuaries. If they are discovered in oysters or any other type of shell-fish, sewage pollution is clearly indicated. Of the various types of coliform bacilli, only the fæcal type is of significance. Fortunately their presence is easily determined. The presence of sewage pollution in all types of shell-fish is a public health hazard which should not be countenanced. Oyster beds should be carefully controlled. Sanitary inspection of the watershed, likely sources of pollution, tidal action and currents, together with frequent examination both of oyster and water samples, is essential. Floated oysters have been implicated in a large number of disease outbreaks, through storage in polluted waters. Control measures should therefore include bacteriological examination of the water used for this purpose.

Oysters will remain alive and edible for lengthy periods if stored under cool conditions. Once they have been removed from their shells spoilage may be rapid. Autolysis plays a part in oyster spoilage, the two processes of fermentation and putrefaction probably proceeding simultaneously. This is due to an increase in the various types of bacteria found in the water and in the soil. Spoilage may be retarded by washing the oysters. If clean water is used, this will reduce the number of organisms present. Low temperatures, below 45° F., also assist in reducing spoilage. Ice is used for preservation. In this connection it should be noted that direct contact of ice with the oysters will adulterate the oyster liquor and increase the risk of infection. A yeast-like fungus may produce a pink coloration in oysters. There is no evidence that such oysters are injurious to health, although, as this fungus does not develop for several days after packing, it will be obvious that oysters affected in this way are not fresh. Because of the fact that other organisms may have developed, shell-fish affected in this way should be carefully examined for signs of decomposition. Oysters which have fed on microscopic plants, such as green diatoms, sometimes exhibit a dark olive-green coloration. This condition is non-pathogenic. Normal cooking cannot be relied upon to render oysters safe when they have been contaminated with pathogenic organisms.

Mussels have been implicated quite often in outbreaks of food poisoning. The most common form of disturbance is termed "musselling." This affection is non-bacterial in origin, being due to properties inherent in the shell-fish. The most frequent manifestation is erythema, or nettle-rash, usually accompanied by intense itching. Vomiting and diarrhœa also occur. The illness is of short duration. Some individuals are unusually susceptible to this form of attack and should avoid eating mussels. A similar type of illness occurs in susceptible individuals after eating crabs, lobsters and other shell-fish. A second, paralytic form of mussel poisoning sometimes occurs. This may be fatal. Its cause is not definitely known, although it is suspected to be a form of toxæmia. Mussels from foul or stagnant water are invariably implicated. A third form of mussel poisoning resembles bacterial food poisoning. Attacks vary in type from mild to severe. Several fatal cases have been reported. An outbreak of the paralytic type was reported from Wilhelmshaven in 1885, involving nineteen cases, with four deaths. In 1908, an outbreak in the Dublin area affected seven individuals, five of whom died. Symptoms included vomiting, swelling of the face and constriction of the throat, giddiness and spasms being also noted. Death resulted from respiratory paralysis. A similar outbreak was reported from California in 1927, in which 102 persons were affected, with six deaths. Poisonous mussels cannot be readily distinguished from sound molluscs when cooked. Occasionally, however, a pungent odour may be noticeable, while the liver may be large and dark.

Cockles have been implicated in the transmission of typhoid fever. In 1903, an outbreak of this disease was reported from Glasgow. Twenty-five persons were affected, many more suffering from gastro-intestinal disturbances of a non-specific nature. An outbreak of gastro-enteritis due to cockles was reported from Avonmouth in 1936, affecting eighteen persons. The causative organism was *Bacillus proteus vulgaris*.

Great care must be exercised in the investigation of any disease outbreak attributable to shell-fish. The individuals who have consumed such fish may be reluctant to admit that they have done so, careful and persistent inquiries being called for before the necessary evidence is obtained. In too many instances reports are isolated and open to doubt. All other sources of likely infection must be eliminated before it can definitely be stated that the consumption of infected shell-fish has been the cause of illness. In the case of infectious disease such as typhoid fever it is particularly important to note whether or not the illness has occurred within the appropriate incubation period. In this connection it has been reported that incubation periods may be somewhat reduced in the case of shell-fish infection. The type of shell-fish eaten must always be ascertained, information being sought as to whether it was consumed in a raw or cooked state. If cooked, the method of cooking is important. The source from which the shell-fish was obtained may call for detailed and lengthy inquiries. The beds from which the fish were taken may have to be examined and samples both of the water and of the shell-fish procured for bacteriological examination.

The meat of crustaceans presents a particularly favourable medium for bacterial growth. Organisms can obtain entrance to the flesh after cooking and during handling. Fæcal coliform contamination is commonly the result of unsatisfactory methods of treatment. Other coliforms, not of the fæcal type, may also be present and indicate unsuitable methods of handling. Large numbers of ærobes may be picked up during preparation of the meat and will readily increase in number if storage conditions are unsatisfactory.

Shell-fish Purification

Brief mention has already been made of the methods employed in the purification of infected shell-fish. As it would be difficult to find water in the estuaries round our coasts pure enough for the cleansing of shell-fish, the process is usually carried out in specially-constructed concrete tanks. Both oysters and mussels are able to complete a process of *self-purification*. This is brought about by the passage of water at a suitable temperature through their alimentary systems. In these types of shell-fish, bacteria are concentrated in the body, in the gills and in the liquor contained in the shell. In polluted waters this bacterial content may be higher than that of the water in which the shell-fish are growing. When the water temperature falls below 45° F., the oyster ceases to feed. As the circulation of water is reduced the bacteria present are forced into the digestive tract and are eventually removed by fæcal elimination. This method of self-purification is made use of in the cleansing of shell-fish grown in polluted waters. The shell-fish are placed on wooden grids in a suitable concrete tank and hosed to wash away mud and slime. The mud is washed away and purified seawater is admitted to fill the tank. The shell-fish are allowed to remain overnight in this water which is used to wash out bacteria present within their bodies. This method of treatment may be completed in twenty-four hours if (*a*) the fish are not heavily contaminated, (*b*) the water is clean and at the right temperature, and (*c*) salinity is correct. The water should circulate freely and carry away the polluted material. Hosing again takes place, the tank is again filled, and remains full for a further overnight period. After the second night the water is drained away, a further hosing is given and the shell-fish are left covered in seawater with a chlorine content of three parts per million. This sterilises the outsides of the shells and they are then removed from the tank and packed in bags for transport. The bags have been previously sterilised in one part per 10,000 of chlorine solution. Very cold water is unsuitable for the treatment of oysters, a water temperature of between 50° and 60° F. being necessary.

Chlorine treatment is also used for purification purposes. The shell-fish are treated with chlorinated sea-water, the water in which they are relaid, their shells and any polluted material being sterilised by this means. This process has already been discussed on pp. 125 to 126. It should be remembered that in itself this will not render the shell-fish safe, the process requiring assistance from the self-purification efforts of the mollusc. The chlorine does not enter the shell-fish or affect its flavour but, rather, cleans the water, with which the fish cleanses itself.

Ozonisation treatment for shell-fish purification has also been used, sand-filtered ozonised sea-water being passed over trays in which the shell-fish are laid. The period required for cleansing varies from forty-eight to seventy-two hours. The treatment is both effective and economical.

Cockles and other shell-fish are sometimes subjected to a *sterilisation process* by steaming under pressure in suitable autoclaves. When properly carried out this method is effective.

Cleansing stations for the treatment of shell-fish have been established on a commercial basis at Conway, Lytham and at Brightlingsea, the latter station being entirely used for the purification of oysters. Shell-fish purified by any of the above-mentioned methods are not impaired either as regards keeping quality or flavour.

CHAPTER XI

MILK PRODUCTION AND DISTRIBUTION

THE production and distribution of milk is one of the major industries of this country. The population of these islands has never shown any great fondness for milk, which has no great place among the beverages consumed by adults, being mainly regarded as a food for infants and invalids. Before the public is likely to consume greater quantities of milk, it must feel confidence in the safety of the supply. It should also be realised that the more milk is consumed the lower will be the cost of distribution. The magnitude of the industry, which enables milk to be delivered daily at the door of the consumer, is not fully appreciated by the general public. Before the War the total value of the tangible assets used directly in the production, transport, processing and distribution of milk approached £400,000,000. At present there are approximately 160,000 milk producers in Great Britain, the number of persons employed by them being in the region of 300,000. A further 150,000 people are engaged in transport, processing and distribution of milk, so that in all approximately 450,000 persons are employed by the industry. It has been estimated that 85 per cent. of cows in this country are maintained solely for milk production. These are divided into a number of herds of different sizes. Records show that the bulk of milk available for use is produced in small herds, 36 per cent. of which contain less than 10 cows, and 45 per cent. between 10 and 25 cows. Of the remainder, 15 per cent. contain between 25 and 50 cows. Only 4 per cent. consist of more than 50 animals.

The efforts of one man backed by £100 to £150 of capital are required to produce and distribute 1 gallon of milk to the consumer. On the production side it will thus be obvious that the industry must rely for the greater proportion of its milk upon the small producer. So far as distribution is concerned, the tendency is for this work to be handled more and more by large firms who possess sufficient capital to discharge their responsibilities to the public in an efficient manner.

Milk is an amphoteric liquid and is the food designed by Nature for feeding the young from birth until weaned. It is produced from the lacteal glands of the cow after calving. Cows yield milk for periods up to twelve months, the average yield for an animal in good condition being approximately 2 to 3 gallons per day. Far too many cows must at present be classed as unproductive, giving very low yields, which are a poor return for the feeding-stuffs supplied. Present policy tends towards herd improvement with a view to increased production. Good milk is yellowish-white in colour. It is an opaque liquid possessing a fresh smell when sweet, with a bland sweet taste. If milk is allowed to stand for a few hours, the cream, or butter-fat, rises to the surface. The remainder of the milk is less opaque, being whitish or bluish in colour. In milk, the first portion removed from the udder is termed the "foremilk." This is bacteriologically poor. The second portion is known as the "middle milk" and is of fair quality. The third part, known as the "strippings," is very rich in fat. The proportion of fat varies throughout the year by as much as 0·5 per cent., the lowest fat content being present in the period April to June, when the quantity is greatest. The fact that animals are turned out to grass in the spring is often urged in defence of poor quality. This, however, exerts little effect upon the milk if suitable concentrated foods are provided. Weather conditions do not affect quantity or quality. During the early spring months there is, however, an increasing difficulty with low solids-not-fat. This problem seems at present incapable of ready solution.

Dairy Herds

The principal breeds of cattle used for dairy purposes at the present time have only been evolved by a slow and gradual process which has taken many years to complete. Although eminently satisfactory progress has been made, these breeds cannot be regarded as final, since breeders are continually making efforts to improve stock. Cattle have been domesticated from very early times, being chiefly used for meat. Their value as milk producers was not realised for some considerable time, and not till then were attempts made to evolve an animal which would yield a profitable supply of milk. This evolution has received considerable assistance from the fact that suitable climatic conditions and a plentiful supply of natural food are to be found in this country. From the general division of domesticated cattle into dairying, beef-producing and general-purpose types the science of milk production has carried matters much further, so that it has now been possible to determine the special qualities of milk from the different breeds.

Generally speaking, the majority of cows used for milk production in this country are crossbreds and retain very little of their original strain. The most useful breeds for dairying purposes are Friesians, Ayrshires, Shorthorns and the Channel Islands breeds of Jerseys and Guernseys. These in their thoroughbred types are good animals, although modern milk production is not the prerogative of these breeds. Far too many crossbred herds exist. A substantial proportion of milk producers buy ready-made milking cows without paying any attention to their ancestry. When all possible milk has been obtained from such animals, they are sold in the markets, additional cows in full milk being purchased. It would be more profitable if producers retained animals showing a good yield of quality milk, using them as reproducers of further stock.

Dairy cattle are subject to many forms of disease which have an important influence upon the milk supply. Owing to disease, the average productive life of a dairy cow is limited to four and a half years, the numerous ailments to which such animals are liable being responsible for annual losses amounting to many millions of pounds. There is also the further danger of infection of the consumer. Some of the diseases affecting milking cattle can also affect the consumer. The three most important diseases in this category are tuberculosis, mastitis and contagious abortion. *Tuberculosis* is widespread in the dairy herds of this country, the incidence being in the region of 30 per cent. All affected animals do not secrete infected milk but, due to the prevalent system of bulking milk, it is estimated that between 6 and 7 per cent. of all market milk contains living tubercle bacilli. It should also be borne in mind that, although infected animals may not be secreting tuberculous milk at any given time, they are potential infective agents. Further evidence shows that the incidence of tuberculosis among dairy cattle is decreasing very slowly.

Mastitis is important for two reasons. It considerably reduces the quantity of milk produced and, while not generally infective to human beings, outbreaks of septic sore throat caused by organisms present in bovine mastitis have been reported. Udders affected with mastitis become swollen and painful to the touch, in this way differing from an infection of the udder with tuberculosis, in which the organ is swollen but can be freely handled. Tuberculous milk usually appears normal ; the milk from an udder affected with mastitis is flaky or clotted in appearance, has a salty taste and keeps badly. It has been estimated that approximately 40 per cent. of cows in this country suffer from some form of mastitis, which is quickly spread during milking operations, particularly if a milking machine is used and methods are unhygienic. *Contagious abortion* causes great loss to the dairy industry, as cows slip their calves. Breeding from affected animals is rendered difficult, while serious interference with the flow of milk occurs. This disease is most infectious to cattle and may quickly spread throughout a herd. It is also infectious to human beings, causing undulant fever. Quite a number of other diseases affect the productivity of cattle but rarely affect human beings. These include cow-pox, foot-and-mouth disease, actinomycosis, anthrax, rabies, milk fever, sterility and *digestive infections*. It is probable that only the digestive affections can be transmitted to human beings in milk. Symptoms of food poisoning following the consumption of milk from animals suffering in this way have been reported both in this country and abroad.

The secretion of milk is intimately connected with the physiological condition of the producing animal. The mammary glands, in which the milk is produced, are composed of branching ducts lined with secreting cells. The ducts further branch into smaller tubes which end in alveoli, these being surrounded with numerous capillaries. The milk is elaborated from the blood and diffuses from the capillaries into the gland cells, where it is chemically changed into milk, passing into the interior of the alveoli and finally, by means of various ducts, into the gland cistern situated above each teat. This storage reservoir connects with the teat canal. The milk can only be removed by pressure on the muscle which closes each teat.

Premises

It has been stated that the buildings in which milk is produced exert little or no effect upon its final quality. While there is some truth in this statement, it is equally true that good buildings are more likely to favour hygienic methods of production. It should always be remembered that the aim of milk producers should be to produce clean milk of good keeping quality, free from pathogenic bacteria. One of the principal requirements for the production of milk for human consumption is cleanliness. Many existing cowsheds and dairies, particularly in our rural areas, where the bulk of milk is produced, are of unsatisfactory design and construction and certainly do not lend themselves to the hygienic production and handling of milk. The majority of cowsheds in this country are relics of a period during which hygiene on the farm was non-existent, and during which labour was so poorly paid that it was not considered expedient to arrange for its proper utilisation. Such cowsheds are far from satisfactory, their proper cleansing is difficult, drainage is almost non-existent, while lighting and ventilation are in direct contradiction to accepted hygienic principles. It is therefore not surprising that difficulties exist in maintaining healthy herds and that the production of clean milk is rendered difficult, if not impossible.

The site and aspect of a *cowshed* should be similar to those required for the erection of a dwelling-house, with easy access to the site. Single-range cowsheds should run from east to west ; double-range buildings should preferably range from north to south, so that maximum light is available on both sides of the building. The size and planning of the structure primarily depend upon its type, upon the breed of cattle to be housed and their numbers and upon the space available for erection. Cubic space, and particularly ventilation, are important. It is usual to allow a cubic capacity of 600 to 800 cubic feet per cow, although air space is not so important as efficient ventilation. Provision must therefore be made for a sufficient number of inlets and outlets to allow of the air of the building being regularly changed. Windows should be made to open, while ridge outlet ventilation should be provided where possible. Adequate natural and artificial lighting must be provided. Natural lighting should be adequate during all daylight hours.

Buildings and internal fittings should be constructed from the best available materials. Floors should be of concrete with suitable falls for drainage. The drop from the standing to the gutter at the heelstone should not be less than 6 inches in depth. The gutter should be 3 feet in width, while a suitable wide walk at the rear of the cattle is essential. All corners and ledges should be closed by filling with concrete. Divisions should be constructed of tubular steel or concrete ; the walls should be cement-rendered to a height of at least 4 feet 6 inches. Water bowls provided with a suitable water supply as well as feeding troughs are essential. The water supply should be adequate and of suitable purity. An average daily supply of 30 to 35 gallons per cow is essential in modern dairying practice. Cleanliness is assisted by a good water supply, and it is to be regretted that many rural areas are still without adequate mains supplies. This is important, as many private supplies in these districts may be grossly polluted. The cost of providing water to all farms should be a national charge, as the production of milk is mainly carried on in those areas least able to bear the burden of providing sufficient mains supplies. Drainage is also important. All floor washings, urine, etc., should be removed to a suitable point of disposal at some distance from the premises.

Many herds are maintained in *covered or partly-covered yards*. This method encourages healthy cattle and saves considerable labour. Cattle can only be maintained in this fashion in districts where the climate is not too inclement and where a sufficient quantity of straw is available for bedding purposes. The method has much to commend it, especially where the producer is faced with considerable expense in renovating existing buildings or in erecting a new cowshed. A milking parlour and dairy are usually provided for use with cattle yards. In some parts of the south-west of England cattle remain out in the fields during the whole year, being milked in the open air. This method improves the health of the herds provided the land on which they are maintained is suitable for the purpose. Whether or not this method assists in the production of milk of good keeping quality remains in doubt. *Milking sheds or parlours* are not essential but can be an aid to clean milk production. The bulk of the country's milk supply is produced without such assistance. The requirements of a building used as a milking shed closely resemble those laid down for cowsheds, although the structure need not be so elaborate as the animals are only housed in it for two or three brief periods each day. It has been stated that the provision of a milking shed is a luxury which most milk producers cannot afford, but nevertheless the provision and proper utilisation of a milking shed can be of definite use as an aid to providing milk of good keeping quality.

Too many farms at present lack a suitable *dairy* ; too much milk is handled and too many utensils stored in the farm-house kitchen, the milk producer failing to appreciate the true importance of a separate building for this purpose. In the past too much reliance has been placed upon some portion of the farm-house, often situated at a considerable distance from the cowshed. Utensils are also stored in any convenient shed, however ancient and unsuitable, adjoining the cow-house. It is also a fact that many existing dairies are still being used as general stores. The conditions found are often deplorable and provide an almost certain source of milk contamination. The cleansing of milk utensils and body linen is often carried out in the same room as that in which milk is stored, while the water used for utensils washing is frequently heated in a copper employed for boiling dirty clothing. There is a curious lack of reasoning on the part of certain producers, who will spend considerable sums on stock and a suitable cowshed but who cannot be persuaded to appreciate the need for a dairy building. Such individuals cannot properly understand that, in addition to clean milk production, milk must be stored and handled under suitable conditions. Dairy buildings, which need not be elaborate, should be constructed of suitable permanent materials on the lines employed in cowshed erection. For herds not exceeding twenty cows a dairy consisting of one room will suffice. For larger herds and for producer-retailers two rooms of suitable size are required, exclusive of any boiler-house which may be necessary. The floor should be of concrete with suitable falls for drainage to an external trapped gully. The walls should be cement rendered to a suitable height. Adequate lighting and ventilation should be provided. Internal angles should be rounded to prevent the accumulation of dirt and filth. Means of heating water in the dairy should be readily available together with an adequate pure water supply. This is required for cooling purposes. Steam should be provided for sterilisation of the utensils after they have been washed, although sodium hypochlorite solutions can also be used for this purpose.

Many buildings at present in use are in need of urgent reconstruction. In many cases the buildings should be treated as insanitary property and demolished. When cow-keeping for milk production was first begun, these buildings were erected and used for a variety of purposes. As the demand for milk increased the buildings were converted, often in an unsatisfactory manner and without due provision being made for the future. The best methods of conversion were rarely considered or even understood, the sole point at issue being the speedy transformation of the buildings into a profit-yielding asset. The result has been that many farmers are now saddled with a legacy of the past which is proving a liability. The disappearance during the War of farm-house cheese making and butter manufacture, together with the remunerative prices obtained for liquid milk, caused many producers of these commodities to turn to milk production. In the majority of cases the buildings used were entirely unsatisfactory, while the methods employed left even more to be desired In addition to such wholly unsatisfactory premises, there remain many buildings which should be improved to some degree, while many of those which have been reconstructed in order to bring them into line with modern requirements are now in need of alteration The reconstruction of old buildings presents a variety of problems. In some instances the cost of reconstruction may be greater than the erection of a new building. It is therefore essential that a comparison of costs should be made before any work is attempted. As with new buildings, floors, lighting and water supply are of primary importance in reconstructed premises. Difficulties can usually be overcome if common sense and a broad outlook are brought to bear upon the problems as they arise. The healthier stock, economy of labour and the cleaner milk which should invariably result will well repay any expense and trouble incurred.

Inspection

The inspection of cowsheds and dairies is important for a number of reasons. Such inspection encourages a reasonable standard of sanitation and stresses the simple, inexpensive yet vital principles of cleanliness necessary to ensure hygienic standards of production. Inspection also ensures the protection of the community by safeguarding the production of an essential food. There has for many years been a serious lack of uniformity in methods and frequency of inspection. This irregularity has caused intense dissatisfaction among producers, especially in adjoining districts. Many reasons exist for the lack of proper inspection, principal among which are shortage of staff, lack of interest on the part of those responsible, and the absence of a definite lead from the central authority. The transfer of powers to the Minister of Agriculture and Fisheries will, it is hoped, result in greater uniformity and cohesion.

Inspecting officials have to deal with two types of individual. The majority of milk producers and distributors are amenable to reasoned arguments and are willing to learn and practise new ideas, always provided they are better than those in use. This type of individual can be adequately dealt with by the application of educational measures. Most of their mistakes occur through ignorance and are readily put right when attention is drawn to the point at issue. Any suggestions made, however, should invariably be accompanied by the reasons which have prompted them. The second type of producer and distributor includes those who are not amenable to reason, who will not move with the times and who are indifferent to progress. These recalcitrant individuals prefer the crude methods of their forefathers and cannot be moved by education or advice. There are still far too many of this type handling milk, greatly to the detriment of those who exert every effort to produce and market a good-quality article. Compulsion is the only means available for dealing with such persons. Apart from ethical considerations, the interests of the milk trade and of the nation as a whole demand the immediate abolition of this class of producer.

When any inspection is made, attention should be particularly directed to certain important factors. The animals should be healthy. In all premises there should be an entire absence of offensive odour due to lack of cleansing or inadequate ventilation. The buildings should be light and airy, the animals contented in appearance. The floors, feeding troughs and walls should be clean and should display evidence of personal interest on the part of those responsible for their maintenance. Any lack of care or unsatisfactory conditions should immediately be brought to the notice of the person in charge. The utensils should appear visibly clean. Inspection alone is not sufficient, particularly in the case of utensils. Such inspections should always be supported by laboratory control. The most satisfactory results can only be achieved by the exercise of common sense and tact rather than by the application of available legislative powers. The inspecting official should always work with the individual concerned, if this is at all possible, rather than against him. If the administration is fair and just the official will be a welcome visitor, the advice tendered being readily accepted and put into practice. Producers should be encouraged to look upon the inspecting officer as a friend and adviser rather than as someone who calls periodically to demonstrate the power of the law. Stringent action should, however, be taken against the wilful law-breaker, who is an ever-present menace to the community. Milk production and distribution is on the whole a difficult calling, those in charge having many serious problems to face. This should be remembered by inspecting officials.

Clean Milk Production and Distribution

Milk should always be produced under the most cleanly conditions possible. During the last few years the necessity for the practice has become even more clamant, owing to the increased quantity of milk required for consumption and the prevention of any wastage through souring. The poor keeping quality of milk has in the past tended to affect consumption in an adverse manner. This defect, which is largely due to carelessness on the part of those concerned in production and handling, has prevented the public from gaining confidence in the milk supply generally. Keeping quality depends entirely upon the cleanliness of the milk, which in turn depends upon the methods used in its production and distribution. Lack of keeping quality has caused enormous losses due to premature souring. It is frequently stated that the extra labour involved in producing and maintaining milk in a clean condition is unduly expensive. This belief is erroneous. Clean milk *can* be produced by any person having the will to succeed together with the fixed determination to apply consistent effort.

Clean milk does not mean milk in which all visible dirt is absent, nor does it imply milk from which visible dirt has been extracted. The term should be confined to raw milk from healthy cows which has been produced and handled under hygienic conditions, which contains only small numbers of non-pathogenic bacteria and which is capable of remaining sweet from delivery to delivery in summer, and for four or five days in winter, without being treated by heat. The sources of milk pollution are so many and so varied that, if due care is not taken, its bacterial content will very quickly assume serious proportions. If those responsible for the handling of milk exercised strict hygienic methods at all stages of its journey from the cow to the consumer, significant addition to the numbers of bacteria already present in the milk could be avoided. Almost all the troubles experienced by the producer, distributor and consumer of milk are due to the activities of organisms which could, by the exercise of care, be very largely excluded from milk. The character of milk changes from the moment it leaves the udder in proportion to the number of organisms which obtain entrance to it. Some of these organisms may be definitely pathogenic, some may be potentially harmful, whilst others cannot be considered as having any detrimental effect *per se*. The conditions most likely to accelerate bacterial growth, i.e. warmth, moisture, air and nutriment, are all found in milk, which is one of the most favourable media for the support of bacterial life.

Primary sources of contamination occur at the point of production. The *air* of the cowshed and dairy may produce pollution, while an unsatisfactory *water supply* used for cleansing dairy utensils may be the means of spreading disease. The air of the cowshed should therefore be maintained in as pure a condition as is practicable, the shed being always kept in a clean condition. *Ventilation* is of considerable importance. Care must be taken to ensure that the movement of dusty materials immediately prior to or during the milking is not allowed to pollute the atmosphere, and that the dairy is kept scrupulously clean at all times. Steps must be taken to ensure the purity of the water supply. The *animal* itself is most important. An unhealthy animal or an animal suffering from any disease of the udder can add countless pathogenic organisms to the milk. Even healthy cows are responsible for many of the organisms found in milk. If proper care is not exercised, the habits of the cow and the surroundings under which it is kept tend to increase the bacterial content. Animals are often confined to the cowshed for most of the year. Being fastened in one place, they have to feed, sleep and perform their natural functions wherever they may be. They cannot avoid soiling their udders and hindquarters, the organisms present on manure particles readily gaining access to the milk. In addition, bacteria adhering to the udder find their way into each teat canal and are discharged with the first few draws of milk. This foremilk should not be mixed with the bulk supply. All dairy cows should be healthy. Their flanks and udders should be clipped regularly, and prior to each milking they should be groomed. Their udders should be washed with warm water containing sodium hypochlorite solution, a clean cloth being employed for the purpose. The washing water should be frequently changed. An udder with a surface which is damp but not wholly wet is desirable. A separate cloth should be used for drying the udder before milking is commenced.

Milk may also be contaminated during *milking operations*. Such contamination arises from the flanks, hindquarters and udder of the cow, and from the dust which may be present in the air of the cowshed or dairy. The milker's clothing and person represents a third possible source of contamination. The practice of milkers or dairy hands proceeding direct from farm duties to milking with dirty or dusty clothing is to be deprecated. This practice presumes a steep rise in the bacterial content of the milk. Clean overalls made from some washable material, together with a cap, should always be provided and worn. The hands of the milker, especially an individual suffering from a communicable disease, also add their quota of bacteria and may affect the health of the consumer. Similarly, any person employed in handling milk can affect the liquid during its distribution. All persons employed in dairy work should be healthy and should be clean in their persons and clothing. Strict supervision of health and habits should be maintained. The frequent washing of hands, for which adequate facilities should be provided, is essential during milking and handling operations, while medical examination of all employees should be undertaken at periodic intervals. Wet-handed milking should not be countenanced. This is a noxious practice, likely to cause serious contamination of the milk. Dry-handed milking will not produce sore teats, as has so often been stated, but will assist in the production of a cleaner liquid.

Milk should be removed from the cowshed immediately after production to minimise the risk of air-borne contamination. Utensils are among the most frequent sources of milk pollution, since, if milk or milk residues are allowed to remain on their surfaces, bacteria flourish and are subsequently added to the milk. The employment of straining cloths, which are rarely clean, or of wire-gauze strainers add their quota of bacteria to milk.

Galvanised buckets are frequently employed but are difficult to clean. If hand milking is practised, covered pails should be used, the opening being as small as practicable and almost vertical. The cooler should be provided with large corrugations so that the fingers can reach all parts of the metal surfaces during cleaning operations. It can be stated that the bulk of milk contamination is due to lack of cleansing of the various utensils which come into contact with the liquid. Too much use is made of cold water only, hot water in conjunction with a suitable detergent being essential for the satisfactory removal of greasy residues. The employment of steam sterilisation has tended to obscure the necessity for a thorough cleansing of the utensils by scrubbing prior to this process being applied. When steam is used, the sterilisation process should be thorough, the correct temperature being maintained for the requisite period. Cleansing assumes even greater importance when hypochlorite solutions are employed, since these liquids will not act efficiently in the presence of milk solids. The most difficult piece of apparatus in use so far as cleansing is concerned is the milking machine. Owing to their many crevices, pipes and angles, milking machines are frequently contaminated with milk solids, and therefore with bacteria. Frequent dismantling of these machines is essential if suitable cleanliness is to be guaranteed. Dirty milk bottles and churns also add their share of organisms to milk. Even in well-managed dairies churns are usually far from sterile, while bottles are not always satisfactory. In smaller dairies bottles and churns are often washed in a slipshod, careless manner. Containers are a frequent source of pollution of what might be otherwise good milk.

Cooling arrangements are especially important. Even when used in a proper manner, the cooler may produce contamination, particularly if it has not been properly cleansed and sterilised or if it has been stored in a dusty place. A leaky cooler, which allows water to gain access to the milk, may cause both adulteration and pollution. The majority of coolers employed on farms and in the smaller retail dairies rely upon water as a cooling agent. If this cooling medium is obtained from a mains supply, its temperature is often too high during the summer months. More use should therefore be made of refrigerated cooling, either of the surface or the immersion types. It must also be remembered that many farms have totally inadequate or unsuitable water supplies and that no attempt can be made in these circumstances to cool the milk. A cheap refrigerated cooler which does not require water for its operation is urgently required. It should be particularly noted that cooling does not decrease the bacterial content of milk but only retards for a period the development of any organisms which may be present.

The mode of *delivery* of milk to the dairy or consumer can permit existing contamination to develop or increase. Present methods of transport leave much to be desired. Milk in churns is too often collected from the farms after standing in the open air or in strong sunlight for a considerable period. It is then transported in open lorries, unprotected from the sun's rays. Churns are often returned to the farms in an unclean condition, although this does not excuse laxity on the part of the producer. In addition, considerable delay frequently ensues before the milk is unloaded at the dairy or collecting station. Similarly, the delivery of milk in open vehicles, either from the churn or in cans, should cease, being replaced by bottled milk. It will be seen that methods of transport represent one of the weakest links in the chain of milk distribution. Drastic improvements should be made at an early date.

The *distributor* can add appreciable contamination to what may be originally clean milk by the use of dirty utensils and bottles. If a distributor receives a clean article from the producer, it is his duty to protect it from contamination during storage and during delivery to the consumer. As indicated above, the method of delivering milk from churns or cans should cease, clean suitably-sealed containers being substituted. Similarly, shops should not be allowed to sell milk other than in properly-closed containers. Milk sold from open receptacles during delivery is in constant danger of pollution. When sold from uncovered basins in general shops, milk may be readily polluted from the atmosphere or tainted from the conglomeration of odours usually met with in such premises.

The *consumer* is not always free from blame in the matter of contamination. Dirty receptacles and unsuitable storage places aid in the rapid increase of any bacteria which may originally be present. The practice of leaving milk open to contamination by flies is still too common. Education of the consumer, side by side with the provision of adequate storage and refrigerating facilities in the home, are clearly indicated.

Designated Milks

In an ideal community milk would be of one grade, i.e. the best which it was found possible to produce and deliver to the consumer. It says little for the general milk supply of this country that certain specially-approved grades are officially defined in order to protect the consumer against low-grade supplies. The present officially-recognised grades of milk and the conditions applicable to their production are :—

(1) *Tuberculin-tested*

(*a*) The animals in the herd must be tuberculin tested at least every six months, the reactors being removed from the herd.

(*b*) The animals must be clinically examined at regular intervals.

(*c*) The premises must comply with the requirements of the Milk and Dairies Regulations, 1949.

(*d*) Milk must be sold in bottles. If bottled by a distributor, it must be forwarded to his premises in sealed churns.

(*e*) The milk must be labelled with the designation and name and address of producer or distributor.

(*f*) It must satisfy the methylene-blue test carried out in the recommended manner.

A sub-division of this grade is entitled Tuberculin-tested (Farm Bottled). Such milk, while complying with the above conditions, must be bottled at the point of production, and bear the producer's name and address.

(2) *Accredited Milk*

(*a*) The animals in the herd must be clinically examined by a veterinary surgeon every three months if the milk is sold in its raw condition, or every twelve months if the milk is to be heat treated.

(*b*) If sold under the designation "Accredited," the milk must be bottled either by the producer or distributor, suitably labelled with the designation and name and address of producer or distributor.

(*c*) The milk must satisfy the requirements of the methylene-blue test.

After September 30th, 1952, licences for the production of Accredited milk will no longer be issued.

(3) *Pasteurised Milk*

This grade, together with *Tuberculin-tested* (*Pasteurised*) *Milk*, receives more detailed consideration in the following chapter. The licensing conditions are set out on p. 157.

(4) *Sterilised Milk*

This type of milk has only received recognition during recent years. It is further considered in the following chapter, pp. 169 to 170.

Tuberculin-tested milk is the highest grade of raw milk produced in this country, a higher grade in Scotland being known as *Certified*. Unfortunately, none of the raw milks can be guaranteed free from disease-producing properties. Instances have been reported of the presence in such milks of tubercle bacilli, while under existing conditions of licence no guarantee of freedom from the organisms responsible for mastitis and contagious abortion exists. There is a real need for more frequent tuberculin tests of animals, while compulsory protection against other types of animal diseases should be provided. Available evidence shows that the present bi-annual tuberculin test is insufficient, since in the case of animals yielding tuberculous milk the disease must have reached the udder in the great majority of cases. If a more frequent test had been applied it is probable that the affected animals would have been detected at an early date, before the disease had advanced so far as to affect the milk supply. There is no clause in the conditions of licence which prevents reacting cattle removed from the herd from being sold in the open market. Early provision should be made for animals of this type to be branded so that they may be readily identifiable. A producer who sells ordinary milk in addition to his graded product is allowed to add reacting animals to his non-designated herd. This practice is common, is totally wrong and should not be tolerated.

The present grade of Accredited milk is not a product of tuberculin-tested cattle, since only a clinical examination of the animals in the herd is considered necessary. Clinical examinations cannot be regarded as entirely satisfactory, since cases of tuberculosis are difficult to detect unless the disease is in an advanced stage. Accredited milk is nothing more than clean milk and, as such, should not be sold under a special designation, which is misleading to the consumer. Savage has shown that Accredited milk is more often contaminated with tubercle bacilli than is ordinary raw milk. Permission to use this designation is not equitable to those producers of tuberculin-tested milk who are making every effort to produce as good an article as is possible under present conditions. It is pleasing to note that, under the terms of the Regulations dealing with designated milks, the use of this designation will cease in a few years' time. Similar criticism applies to standard milk, the equivalent grade in Scotland.

Sales of designated milks have not kept step with the quantity produced, although the total is low when compared with the amount of milk produced annually. This lack of demand has resulted in large quantities of designated milk being bulked at creameries with ordinary raw milk. There is some prospect that this wastage will now cease with the enforcement of the terms of the recent legislation by which the Minister of Food is empowered to delineate areas in which all milk sold by retail must either be Tuberculin-tested, Pasteurised or Sterilised. The same legislation allows Accredited or Standard milks from a single herd to be sold for five years, but states that such sales must cease at the end of that period, i.e. September 30th, 1954. The proposed changes will take several years to complete, although certain positive results are likely to follow more quickly. There is likely to be an appreciable demand for tuberculin-tested milk over and above the present quantity produced in specified areas ; the same can be said of pasteurised and other heat-treated varieties. Consumers will be compelled to choose one of the specified grades for their own use. The sale of ungraded raw milk of doubtful value will then be mainly confined to the extreme rural areas, although it is likely that tuberculin-tested milk will be available, even in these districts, in due course.

Composition of Milk

The composition of milk is subject to considerable variations, depending upon a number of circumstances. Even when its constituents are mixed in the correct proportions, it is not possible by means of an artificial mixture to reproduce milk. The principal constituent of milk is water (average 87·2 per cent.). It also contains fat (3·9 per cent.), sugar or lactose (4·75 per cent.), mineral salts (0·75 per cent.), nitrogenous compounds (3·4 per cent.), enzymes and vitamins, together with other minor constituents. The milk- or butter-fat contains carotene or colouring matter in addition to certain fatty acids ; the main nitrogenous compounds are casein and albumin.

Certain *enzymes* or ferments are also present in milk. These play a part in controlling fermentation. The enzymes found in milk are lipase, galactase, amylase (which is increased in quantity in milk from diseased udders), catalase, peroxidase, phosphatase (useful in determining the efficiency of pasteurisation), reductase, diastase and lactase. Milk is reasonably well supplied with *vitamins*. Vitamins A, B_1, B_2 (G), C, D and E are present. Vitamin A is heat-resistant and contains the previtamin carotene, responsible for the coloration of milk-fat. Vitamins B_1 and B_2 (G) are moderately heat-resistant and are present in adequate quantities. Vitamin C, which is sensitive both to heat and oxidation, is not present to any marked degree and is variable in amount. Vitamin D, together with its provitamin cholesterol, has no resistance to heat and is affected by oxidation. Milk is not a valuable source of vitamin D, although its content can be increased by sunlight and by the feeding of green food to cattle. Irradiation can also be used to effect an artificial increase. Vitamin E is also present in milk.

Milk-fat, or butter-fat, is present in the form of small globules of different fats of low melting points. These globules are in suspension, the substance varying according to the breed of cow from which the milk has been obtained. The larger the globules the more quickly does the fat rise to the surface of the milk under normal conditions. If milk is allowed to stand for eighteen hours, approximately 60 per cent. of the fat will rise to the surface. This tendency to rise can be accelerated by heating the milk. The fat furnishes body with heat and energy, contains most of the colouring matter and is a primary source of vitamins A and D. It is composed mainly of the glycerides of palmitic, oleic and butyric acids. The *water* of milk can be separated from the solids by evaporation. *Proteins* are not present in milk in true solution but are in colloidal suspension. They can be separated from the soluble constituents by means of a porcelain filter. The principal protein is casein, although albumen is also present and constitutes one-seventh of the total. Albumen causes a skin to form on milk when it is heated. Globulin, galactin and fibrin are also present in small quantities. The proteins have a high nutritive value, the amino-acids of which they are composed rendering them suitable for growth requirements. They are utilised in the body for building new tissues and for the maintenance and repair of body cells. The *milk* *sugar*, or lactose, exists in solution and can be separated from the whey by the evaporation of the water and subsequent crystallisation. Lactose is less sweet than cane sugar and is readily fermented by lactic-acid organisms, forming lactic acid, the primary cause of the souring of milk. Lactose furnishes heat and energy for the body. The *mineral salts* present exist either in solution or in a combination with casein. They include a variety of salts, particularly those of calcium and phosphorus. When milk is heated to high temperatures, many of these salts are thrown out of solution. Minerals are essential for teeth and bone development, milk being one of the best sources of utilisable calcium. Traces of iron are also found, although milk is poor in iron as well as in citrate of calcium.

Variations in the composition are common and are due to certain variable factors. The *breed of cow* is important. Generally speaking, high yielding animals give milk which has a low fat content. The reverse is also true. This does not mean that the total yield of milk fat from a heavy milker is low, as the yield varies with the breed. The answer lies in selective breeding. With a rising yield the percentage of lactose increases. *Unsatisfactory feeding* is one of the commonest causes of low yields. With inadequate feeding, deficiencies can only be made up by a drain on the animal's bodily tissues. Minerals introduced into the food increase the yield. As minerals are usually incorporated in the feeding compounds, they will normally satisfy the animal's requirements. Feeding for quantity tends to reduce the quality of the milk. *Seasonal variations* produce differences in composition, winter milk being usually richest in fat, while summer milk is greatest in quantity. The *health of the animals* is important. Ailing animals give reduced yields of milk. The *age of the animal* also affects the compositional quality, cows being richest milkers between four and seven years of age. *Efficiency in milking* can effect the composition. Inefficient treatment during milking may cause an animal to withhold its milk. Inefficient stripping is the common cause of early drying-off in animals, and results in milk of poor quality. The strippings, or last-drawn milk, may contain as much as 9 per cent. of fat ; proper stripping is therefore important. Equal *intervals between milking* are to be preferred, although this is not always possible or convenient. Morning milk is usually greatest in quantity, but poorest in fat content. The *period of lactation* exerts a definite effect. Too frequent lactations should be avoided, an adequate period of rest being allowed between each lactation period. The largest amount of milk is obtained during the five months after the birth of the calf. The milk of newly-calved cows should not be added to the bulk until three or four days have elapsed because of the presence of colostrum, an opaque yellow liquid which sometimes contains blood. The *individuality of the cow*, even when the breed is the same, results in considerable variation in the quantity and quality of the milk produced. Day-to-day variations may also occur, differences of up to 1 per cent. in the fat percentage having been observed.

Much of the milk at present sold is abnormally low in butter-fat, although not below the legal standard. It also tends to be low in solids-not-fat. This low solids-not-fat content is of considerable importance, although its food value is apt to be overlooked. Continued breeding for high yields has probably exerted a definite influence in this direction, although poor feeding, mastitis and bad management are also concerned. There has so far been little inducement for milk producers to provide a liquid of high quality. In the majority of instances, provided the fat and other solids percentages satisfy the legal standard, and provided the keeping quality is satisfactory, no better price, other than that obtainable for the production of designated milks, is received. Those persons who wish to produce high-quality milks must breed for quality, removing low-quality milk producers from their herds and replacing them with more satisfactory animals.

In addition to its chemical constituents, milk possesses a *cellular content* which is present even in the secretions from healthy animals. The types and numbers of such cells vary. The cells separate from the interior of the udder and, if disease is present, the cellular content of the milk is greatly increased. Any such increase provides a useful indication of the presence of disease, although it does not afford positive proof. Experiments have shown that the cellular content of milk rises as the age of the animal increases. An estimation of the number of cells present in the liquid is therefore a valuable aid to diagnosis, especially when conjoined with other methods of examination. The milk of cows a few days after calving shows a marked increase in the cellular content, as does milk from animals which are drying-off. There is also a rise in the number of cells present in the milk from cows which are in the later stages of pregnancy. The strippings show a higher cell content than the fore or middle milk, due to manipulation of the udder during the stripping process.

Nutritive Value

Milk possesses a unique nutritive value when considered in relation to other foods. Its proteins, although not so valuable as those found in meat, contain amino-acids of considerable quality, and in sufficient quantity to supply the needs of the body. Milk protein also possesses high biological value in the enhancement of simple vegetable foods taken in conjunction with it. Whilst cows' milk is the perfect food for calves, it is too rich in protein and contains too little sugar for infant use. For feeding infants, therefore, a quantity of sugar must be added, while the protein content requires modification. Salts both of calcium and of phosphorus are present in abundance and are easily assimilable. In this connection it has been reported that children are unable to obtain sufficient calcium for their needs unless milk is adequately available as part of the diet. Milk contains very little iron or copper but has a plentiful supply of vitamins A, B_1 and G. The vitamin C content is not high and may be absent by the time the milk is consumed. The quantity of vitamin D present in milk is not high or sufficient for human needs, the amount varying according to the degree of sunshine available and the animals' feed. The lactose present is useful as it assists in the development of those internal organisms which inhibit the growth of pathogenic types. Galactase, which is also present, is essential to the proper development of nerve and brain tissue. Milk is particularly important when consumed in conjunction with cereals, various types of meat and vegetables, since it can supply certain types of amino-acids which are lacking in these substances.

One pint of milk contains seven-eighths of the calcium, more than one-quarter of the protein, slightly less than one-third of the riboflavin and more than one-fifth of the vitamin A which nutritional experts recommend for a moderately active man. This quantity of milk supplies one-seventh of an adult's daily needs and one-third of a child's requirements. Milk is a good tooth and bone builder, being exceptionally rich in calcium. Milk averages approximately 13 per cent. of solid matter, considerably more than is present in certain vegetable foods, such as carrots, onions, cabbage and tomatoes. The fact that milk contains more vitamin A than most types of food is of considerable importance, as most of our staple foods are deficient in this vitamin. Milk is a reasonably good muscle builder because of its protein content.

A number of feeding experiments have been carried out in schools in this country which have demonstrated in a practical manner the value of milk as a food. In one large boarding-school Dr. H. C. Corry Mann divided the boys whose ages varied from six to eleven years into seven groups. Each of these groups received a normal daily diet, six with the addition of other foods. One of the groups had 1 pint of milk added to the diet. Observations were carefully made over a period of twelve months. At the end of this period the gains in height and weight of the boys in each group were recorded and compared. The group fed on a normal diet gained an average of $3\frac{3}{4}$ lb. in weight and grew an average of $1\frac{3}{4}$ inches. Those who had received the extra pint of milk gained an average of 7 lb. and grew an average of $2\frac{5}{8}$ inches. The increased gain in height and weight was accompanied by improved health, alertness and high spirits, and exceeded the heights and weights attained by those fed on a normal diet plus any other type of food. Many other feeding experiments with school children have provided corroborative evidence as to its nutritive value.

Fresh foods are always to be preferred to foods containing preservatives. No preservatives are allowed in milk. Its freshness is readily gauged, as any lack of this quality is quickly disclosed by souring. The Ministry of Health Advisory Committee on Nutrition recommended that each child under sixteen years of age should receive and consume at least 1 pint of milk per day, that approximately 2 pints per day were required by expectant mothers, and that the remainder of the population required at last $\frac{1}{2}$ pint per day. As Sir George Newman has stated, the peculiar importance attached to milk as an item of the daily diet lies in its capacity for making good and restoring the balance of the various essential constituents required for adequate nourishment, so often upset by ignorance or prejudice or by actual restrictions in the matter of choice.

Abnormalities in Milk

Because of its food value, milk must be fresh. Milk will readily assimilate a variety of taints or odours which will render it repulsive to the consumer. Milk must be agreeable to the palate and should appear fresh and clean. Abnormalities, including defective flavours, may be due to physiological causes, as in the case of the milk from cows which have had a long lactation period. Diseases or other ailments such as mastitis cause unsatisfactory flavours, as does feeding the animal with certain types of food, such as turnips, fish meal, cider pulp and unsuitable concentrates or weeds. Bacterial abnormalities are common, ropiness, in which strings form in the milk, sliminess, a soapy taste, together with certain discolorations, being due to bacterial causes. The presence of yeasts will produce various types of fermentation. Oxidation during treatment or storage also occurs. The exposure of milk to sunlight occasionally causes it to assume a tallowy flavour, whilst oiliness and a variety of metallic taints may be due to the metals, especially copper, with which the liquid comes into contact. These defects are due to the oxidation of the butter-fat. The process of homogenisation may produce slight oiliness ; sterilisation produces a peculiar burnt flavour known as caramelisation, due to the alteration of the lactose content caused by the high temperatures to which the milk is heated. Irradiation of the milk to increase its vitamin D potency can produce a taint due to over-exposure to the ultra-violet rays used in treatment. If milk is stored in the vicinity of strong-smelling substances such as paraffin, fish or disinfectants, it will absorb such odours to a variable extent and may become offensive to the palate.

Bacterial Content

Milk, being an excellent food, is able to support bacterial life which, under favourable conditions, flourishes with rapidity. Milk from the udder of a healthy cow contains very few organisms, certainly not more than 300 per millilitre. These are likely to hold no danger to the consumer unless the udder of the animal is diseased. After production the liquid undergoes a phase during which the bacterial content may be slightly reduced. It must be emphasised that in normal circumstances most bacteria gain entrance to the milk after it has left the cow. The principal *non-pathogenic organisms* present in milk, even with clean methods of production, are those of the lactic acid type. They normally comprise 85 per cent. of the total present. Such organisms act as a check upon the more injurious varieties present, although as their numbers increase they are responsible for souring. A number of organisms make up this group, of which *Streptococcus lactis*, staphylococci of various types and the coliform organisms represent the chief varieties. Milk also contains a number of spore-forming organisms, principally *Cl. welchii* and *B. putrificus*. These are heat-resistant. Certain types of chromogenic bacteria are found in milk, *B. prodigiosus* and *B. cyanogenes* being the commonest types. These organisms are the cause of abnormal colour conditions and other defects in milk. The main factors which determine the rate of bacterial growth are the number of organisms originally present in the liquid and the temperature at which it is kept. High temperatures favour rapid souring. As certain lactic-acid organisms grow well at temperatures as low as 40° F., milk should be stored at as low a temperature as possible in order to inhibit all forms of bacterial growth. The spore-forming organisms, which are mostly anaerobic, do not multiply rapidly in milk since it is in constant contact with the atmosphere and contains oxygen in solution. Chromogenic organisms are generally of external origin.

A number of *pathogenic organisms* may also be present in milk. These organisms, of which *M. tuberculosis*, *Br. abortus* and *streptococci* of various types are the principal varieties, produce no apparent change in the appearance of the liquid, their discovery being possible only following laboratory examination of the milk. Their presence is due to diseased conditions in the producing animals. Such organisms may be responsible for tuberculosis, undulant fever and digestive affections when the infected milk is consumed. The causative organisms of typhoid and paratyphoid fevers, dysentery, diphtheria, scarlet fever, septic throat and infantile diarrhœa may also obtain entrance to milk through human or other infection of the supply. In addition, the udders of the animals may be infected from human sources with certain types of pathogens. It must always be remembered that, although milk may be produced under hygienic conditions and have a low bacterial content, it may still be dangerously contaminated with pathogenic organisms.

As already indicated, milk may be contaminated with *non-pathogenic* organisms emanating from various sources. Organisms of the coliform group are generally intestinal in origin and find their way into milk from the excretions and bedding. Other organisms are present in the herbage, while the acid-producing organisms gain access to milk from a variety of sources, of which the udder itself is one, others being the coats of the animals, the milkers, the atmosphere of the cowshed and dairy and the utensils. After milk has been produced and during distribution it may be contaminated with organisms from the utensils, churns and bottling machines. Contamination also occurs during processing and can arise from the employees handling the milk. The final point of contamination occurs in the home of the consumer.

The origin of the human *pathogenic bacteria* found in milk is almost invariably human beings, contamination occurring during handling or from the animal's udder, which has been infected by a human agency. The animal pathogens obtain entrance from the animal itself, while certain pathogenic types have their origin in infected water or in the atmosphere.

Contamination of milk after production should be prevented at the point of production, during distribution and after delivery to the consumer. To achieve this end clean, healthy animals and personnel, clean utensils, hygienic surroundings, careful handling at all times and suitable storage in the home are essential.

Epidemiology

Infected milk can be a potent factor in the spread of disease. Many outbreaks have been traced to milk, although the total is not excessive when the quantity of milk consumed daily is taken into consideration. This must not be taken as an excuse for slackness, as the issue is much too serious to permit of any permissible standard short of the optimum. Controlling authorities should not rest content until the possibility of milk-borne outbreaks has at least been minimised and until the even greater danger of tuberculous infection has been finally abolished.

The *characteristics of a milk-borne epidemic* are as follows : The outbreak is explosive in character. A high percentage of the persons affected have the same source of supply, the incidence being usually higher among better-class families, who consume most milk. It will be appreciated that this latter characteristic is not so evident in this country as was the case in pre-war years. The incubation period of the disease concerned may be shortened, women and children, who are the heaviest milk drinkers, being mostly affected. Outbreaks chiefly occur in the smaller towns and in rural districts, where milk is generally sold unpasteurised. When the infected supply is stopped the outbreak quickly subsides. In Great Britain alone nearly 100 outbreaks of milk-borne disease have been notified since 1912. The position is similar in other countries.

Of all the *animal diseases* which can affect our milk supply *tuberculosis* is the most important, the bovine type of organism being almost invariably responsible for non-pulmonary tuberculosis in man. The disease occurs chiefly in children up to five years of age ; above the age of sixteen years there is a progressive diminution in incidence. There has been a marked fall in the non-pulmonary case and death rates during the last few years, due—at least in part—to a realisation of the urgency of the problem. This attitude has been followed by energetic steps designed to prevent or at least minimise the infection of milk with the causative organisms of bovine tuberculosis. Wilson has stated that 6 per cent. of all deaths from tuberculosis are due to infection of bovine origin. If this indeed is the case—and there appears to be no reason to doubt it—65,000 persons died from bovine tuberculosis between 1912 and 1937. It has been estimated that 200 children die annually from bovine tuberculosis, while many more suffer permanent disability. *Brucellosis*, or undulant fever, has been recognised for over thirty years as a milk-borne disease. Since 1917, 219 cases have been notified in this country. During that period there has been a slow but steady increase in the incidence of the disease. Over the same period there has been a corresponding but more rapid increase in the number of cases reported from the Continent and from America. Wilson states that between 400 and 500 cases of undulant fever occur annually in this country, the majority being due to milk-borne infection. It would appear that as the possibility of human infection becomes better known more and more cases are being recognised, errors of diagnosis having probably concealed many cases in the past. Further research relating to the incidence of undulant fever in man is definitely indicated.

Between 40 and 50 per cent. of milking cattle are reported to be suffering from *mastitis* in one form or another. Although the streptococci commonly present in this disease are not dangerous to man, *hæmolytic streptococci* in every respect similar to those responsible for human disease have been found in the milk of animals affected with mastitis. Numerous outbreaks of *septic sore throat* have been traced to milk, many occurring in the form of definite epidemics. In quite a number of instances proof has been forthcoming that the milk of some animals in the herds concerned were infected with streptococci similar to those isolated from patients. Streptococci of a scarlatinal type have been isolated from cases of mastitis in herds. The most notable outbreak of this type in Great Britain occurred in Brighton and Hove during 1929–30, more than 1,000 families being affected, with sixty-five deaths. The epidemic was limited to the customers of one dairy, streptococci being found in the milk of one of the farms supplying the dairy. When the milk supply from the implicated farm was stopped the outbreak subsided. Investigation showed that several cases of illness had occurred among the workers at the farm and that a considerable degree of mastitis was present among the animals. Other notable outbreaks occurred in Colchester in 1905, in Christiania in 1908 and in Massachusetts during 1929.

Cases of *food poisoning* have been reported attributable to milk from cows suffering from intestinal disorders. The causative organisms were those normally isolated in attacks of gastro-enteritis, the mode of entry to the milk being by means of infected fæces. Extensive outbreaks of this type were reported from Aberdeen in 1925, 487 cases being notified, with one death, from Wilton in Wiltshire during 1938, when 132 persons were affected, and from Castlederg during 1949 involving 50 persons. Cases of infection due to cowpox, anthrax and foot-and-mouth disease have also been reported, while the organisms of scarlet fever and diphtheria, infecting the udders of cows, either internally or externally, have been credited with the production of milk-borne disease.

By far the greater number of epidemics have been caused by milk infected with the organisms of *human disease*. *Typhoid fever* and *paratyphoid fever* outbreaks have resulted from the consumption of milk infected either by persons suffering from the disease or by "carriers." Fæces and urine have mostly been responsible, the milk being contaminated by uncleanly habits of those who handled it. The largest outbreak of typhoid fever on record occurred in Montreal during 1927, 5,014 cases being notified, with 488 deaths. An epidemic involving 718 persons, with more than fifty deaths, was reported from Bournemouth during 1936. Both epidemics were traced to raw milk infected with impure washing water polluted by sewage. In the Montreal outbreak a " carrier " was found working in the pasteurising plant concerned during part of the epidemic. Many other outbreaks due to infected milk have been reported from other countries. Paratyphoid fever outbreaks have been reported both in this country and abroad. An extensive outbreak of this type occurred in south-western Essex during 1930, 307 cases being notified. The infection was traced to sewage pollution of the land on which the responsible cattle grazed. *Dysentery* has been spread by milk, eighteen cases being notified at Lynton during 1922, 300 cases from St. Andrews in 1937, and seventy cases from Bedford in 1938. A number of epidemics have also been reported from abroad. Several outbreaks of *diphtheria* due to human infection of milk have been described, five outbreaks being reported from Glasgow between 1907 and 1936. Milk-borne *scarlet fever* has also been notified from several parts of the country and also from abroad, the largest epidemic occurring in Chelmsford and district during 1935, when 487 persons were attacked, of whom six died. *Cholera* due to infected milk has been reported from the Middle East. *Epidemic diarrhœa*, thought to be due to improper handling and fly infestation of the milk, mostly in the home of the consumer, occurs at frequent intervals, especially during the summer months. The precise epidemiology of the disease, which is probably a virus type, is still obscure, although infected milk remains the likeliest cause. Although there is no clear record of attacks of *poliomyelitis* occurring in this country due to infected milk supply, such outbreaks have been reported from abroad. *Food poisoning* organisms can obtain entrance to milk following contamination by persons suffering from mild attacks or from the infected fæces of animals or rats. Milk may also be infected by rats or impure water supplies. A number of outbreaks of this nature have been reported.

Milk Control

The control of milk supplies in England and Wales is carried out by two authorities. Supervision of production methods, health inspections of animals, supervision of buildings and the licensing of designated producers, together with the registration of all milk producers and farms, and the administration of regulations dealing with raw milk are carried out by the Ministry of Agriculture and Fisheries through its county agricultural executive committees and their milk production officers. The distribution of all milk and the supervision of pasteurisation and other forms of heat-treatment are the prerogatives of local authorities and their officers. In Scotland, local authorities are responsible for the production and distribution of milk of all types, as is the case in Northern Ireland.

The work is carried out by means of frequent inspections of premises and methods. It must be stressed that supervision alone is not sufficient as, even when combined with adequate educational measures, supervision cannot provide a full and satisfactory measure of control. Laboratory control is receiving wider attention, but is again not satisfactory *per se*. Whenever samples of milk are obtained for laboratory examination the results must be interpreted in the light of the conditions prevailing at the farm or dairy concerned. The ideal system of control makes use of personal supervision allied to laboratory control. Although laboratory examinations often lead to the detection of improper practices, the results obtained do not yield complete information regarding the methods employed in handling the product sampled. The importance of a combination of the two methods lies in the fact that they serve as a check one upon the other, so that, while neither method is ideal in itself, their usefulness is increased when they are judiciously combined.

Milk should receive a *physical examination* for temperature, taste, flavour and appearance, any unusual conditions observed leading to investigation. Milk may be tested for the presence of sediment, which should not exceed 10 parts per 100,000. Samples should be carefully taken and properly treated prior to examination in accordance with the varying techniques involved. Sterile dipper and collection bottles are essential for bacteriological samples.

Bacteriological control relies upon a number of tests, including the plate count, with such variations as the microscopic count, the microscopic colony count, Frost's little colony count and the Breed smear. Estimation of the coliform content is also undertaken although the significance of this latter test has recently been called into question. Certain dye reduction tests for determining the keeping quality of the sample—as, for example, those which make use of methylene-blue and resazurin dyes—are also used, while the clot-on-boiling and the alcohol precipitation tests are also employed in the determination of keeping quality. Acidity tests are employed for milk-testing purposes, high acidity denoting incipient souring. Various tests are available for detecting the presence of pathogenic organisms, guinea-pig inoculation being employed to determine the presence of the organisms of bovine tuberculosis. Rinsing tests are used to provide information as to the cleanliness of the bottles, churns and other utensils, swab tests being used for the same purpose. Little correlation exists between the different tests employed, these being used to determine different conditions. An all-purpose test which could be used generally is an urgent requirement.

Chemical tests are mainly employed to determine whether adulteration of milk, an illegal act, has taken place. Milk has been found adulterated with cane sugar, glycerine, carbonate of soda, salt, starch, borax, boracic acid, salicylic acid and formaldehyde, although water is the main adulterant. Milk is presumed not to be genuine if it contains less than 3 per cent. of butter-fat or less than 8·5 per cent. of non-fatty solids, unless it is in such condition when obtained direct from the cow. Added water is usually detected by the use of the freezing-point test. In the laboratory the Adams Coil method is employed to determine the amount of butter-fat in a given sample. The butter-fat content can be determined by the Gerber method, although this examination is not sufficiently accurate for analytical purposes or as evidence in court proceedings. The various constituents of milk, such as lactose, ash or protein, are determined by chemical examination, similar tests being employed in the case of preservatives. Chemical examinations are important both as an integral part of any milk control scheme and also as a corollary to bacteriological analysis, upon which they may act as a partial check.

CHAPTER XII

HEAT TREATMENT OF MILK

A CONSIDERABLE quantity of milk for human consumption is processed by treatment with some form of heat. Opinions as to the need for such treatment profoundly vary. The consensus of medical opinion holds that heat treatment is at present essential and that, if efficiently carried out, such treatment would provide a requisite safeguard, applicable at relatively small cost and without seriously affecting the food value of the milk so treated. From a public health point of view, it is imperative that some form of heat treatment by means of pasteurisation or sterilisation be employed. From the commercial aspect, processing is necessary, as much of the milk produced in this country could not otherwise be sold to the customer in a sweet condition, especially when the long distances over which it has to be transported are taken into consideration.

Effect of Heat on Milk

When milk is heated, it undergoes alteration. These changes are influenced by the time during which the liquid is exposed to the heating agent, and by the temperature reached during the process. Milk expands on heating, the co-efficient of expansion being greater than that of water. Viscosity is also lost. A pellicle begins to form on the surface of milk heated in contact with the atmosphere at 140° F. ; the pellicle is completely formed when boiling is reached. This pellicle incorporates a proportion of all the constituents contained in milk, especially albumen. Formation does not occur when milk is heated in a closed vessel. The carbon dioxide contained in milk is driven off during heating, the bicarbonates are partially decomposed, and the constituent calcium and magnesium salts precipitated. This precipitation of calcium salts renders the casein in milk less easily coagulable, while the lecithin and nuclein content is decomposed. At temperatures higher than 145° F., the fat globules are disturbed. The cream-line is progressively affected as the processing temperature rises, although the composition of the milk fat is not altered. Enzymes are destroyed at 175° F. ; at temperatures in excess of 145° F. the percentage of diffusible calcium is reduced. Albumen begins to coagulate at 150° F., increased coagulation resulting from higher temperatures. The heating of milk induces a flavour which is particularly discernible to those individuals with sensitive palates. This flavour varies according to the temperatures attained during the heating process. If excessive heat is employed, a burnt taste, due to caramelisation of the lactose, will be noticed. The freezing point of milk is slightly raised and the acidity reduced at a temperature of 145° F. Prolonged heating of milk at this temperature destroys the bacteria present, in accordance with the period of heating and the temperature attained. The organisms present after sterilisation consist almost entirely of spore-formers and those types which are highly resistant to heat. Prolonged heating of milk at high temperatures destroys vitamins C, B_1, A and D in that order, and precipitates the phosphates. Milk which has been heated forms a finer coagulum in the stomach than does raw milk.

Need for Pasteurisation

All foodstuffs, including milk, should be consumed in as fresh condition as possible. It is essential that the keeping quality of milk should be improved so that, without altering its food value, the liquid may be sold in sweet condition. The ideal would be for all milk to be produced from healthy herds under hygienic conditions and be consumed within the shortest possible time after production. Treatment by heat would be unnecessary if all milk were produced in a hygienic manner, free from pathogenic organisms, particularly those responsible for bovine tuberculosis, and could be delivered immediately to the consumer. Efficient pasteurisation is at present the only method available by which milk can be guaranteed free from disease and souring delayed. When the diseases likely to be spread by milk are considered, it will be obvious that some form of heat treatment is required, at least until a more satisfactory alternative becomes available. By this means milk can be rendered fit for delivery in areas whose supplies must of necessity travel long distances before use. It must again be stressed that pasteurisation is *not* a process which will render dirty milk clean, or sour milk sweet. It should rather be regarded as a means of detecting faulty production methods. It has not been found possible to accumulate any quantity of milk in this country which was free from tuberculosis bacilli ; it has also been proved that even designated raw milks may, on occasion, contain these organisms. Until all milk produced can be guaranteed free from any type of pathogenic organism, pasteurisation or some other form of efficient heat treatment will remain a fundamental necessity. Even where there is no danger of disease arising from milk the process will still be required by virtue of the beneficial effect which it exercises on keeping quality.

Methods of Heat Treatment

Milk may be treated by means of heat in a variety of ways. *Pasteurisation* is now the most popular form of heat treatment. Several methods can be used, of which the low-temperature and high-temperature processes, together with pasteurisation-in-bottle, are legally recognised. In *sterilisation*, which is also officially recognised, milk is heated to high temperatures to destroy all but the spore-bearing organisms present in the liquid. Processed milk is sometimes treated by *homogenisation*. This method is invariably employed in the case of milk which is to be sterilised. The treatment emulsifies the fat globules in the liquid, ensuring an equal cream content throughout the mass. *Stassanisation* is a Continental process by which milk is heated for a very short period at high temperature. It is claimed to be an efficient substitute for pasteurisation by the high-temperature method. Whichever method is employed, care must be taken to ensure that it is not detrimental to the food value of the milk and that the retail price of the product is not materially increased.

Pasteurisation

Pasteurisation is widely used throughout the world. In London alone, at least 95 per cent. of milk is pasteurised before distribution ; in Birmingham, Glasgow and Manchester between 80 and 90 per cent. of milk receives some form of heat treatment. Following the coming into operation of the Food and Drugs (Milk, Dairies and Artificial Cream) Act, 1950, and the delineation of special areas, a substantial increase in the quantity of milk treated in this manner will probably occur.

Pasteurisation takes its name from Pasteur, who first explained the benefits to be derived from the application of heat to certain foodstuffs in relation to the destruction of bacteria. His theories had already been partially developed some time previously. In 1795, Appert heated milk as a means of preservation. During the years 1857 to 1862 Pasteur paid particular attention to the heat treatment of milk. Concurrently with his experiments Borden, in America, carried out similar experimental work. The first commercial pasteuriser was set up in Germany. The process quickly became popular on the Continent and in America and was eventually introduced into this country. The early adoption of the process was due to a desire to retard souring, the methods employed being such as to cause the process to be regarded as a means of salvaging low-grade milks, a belief which exists in certain quarters even to-day. Many years had to elapse before the public health significance of this process as a means of preventing the spread of disease was fully realised.

Pasteurised milk must comply with certain conditions when sold under licence. These are :—

(*a*) The milk must be retained at a temperature between 145° F. and 150° F. for thirty minutes or, alternatively, at a temperature of 161° F. for fifteen seconds. After treatment it must be immediately cooled to a temperature not exceeding 55° F.

(*b*) The milk must be heated once only and not otherwise treated by heat in any way.

(*c*) Suitable temperature-indicating devices and control arrangements must be provided.

(*d*) The milk must be labelled " Pasteurised."

(*e*) The type of apparatus used must satisfy the requirements of the licensing authority.

(*f*) After treatment, the milk must not be placed in any utensil or storage vessel which has been used for raw milk.

(*g*) Samples of milk on examination must satisfy certain specified tests.

Tuberculin-tested (*Pasteurised*) *milk* is defined as milk produced from tuberculin-tested cows which has been treated by the pasteurisation process, carried out in accordance with the requirements set out above. This grade satisfies the demand for the heat treatment of a good-quality raw milk.

Methods of Pasteurisation

Although only two methods of pasteurisation are officially recognised, other methods of treatment are employed. These latter are mainly designed to extend the useful life of the liquid, with no thought of its subsequent safety to the consumer. The various methods are set out below.

(1) *" Flash " Pasteurisation.* In this process milk is heated to a temperature between 160° F. and 170° F. or even higher, and immediately cooled. The milk is not held for any period during its passage through the apparatus. In the usual type of pasteuriser the liquid enters a hollow vertical cylinder at the lower end and is distributed by centrifugal force in a thin film over its inner surface, finally leaving at the upper end. The cylinder is surrounded by a combined steam and water jacket. Such pasteurisers are mostly of Continental origin, the process not being officially recognised for the production of a designated article. The plants are comparatively small when the quantity of milk to be handled is taken into consideration, and are inexpensive to install. They require a generous steam supply for effective working, owing to the small heating surface provided. The excessive heating of the milk causes some of it to be over-

heated, with damage to the cream-line and alterations in the chemical composition. The method should only be used to reduce the bacterial content of milk and to improve its keeping quality. There can be no guarantee that pathogenic organisms are actually destroyed, owing to fluctuations in temperature due to variations in the milk flow through the apparatus. The liquid frequently develops a " cooked " flavour, caused by overheating. Its nutritive value may also be seriously impaired.

(2) *" Continuous-flow " Process.* This method of treatment is little better than the " Flash " method. The apparatus is designed to allow the milk flowing through it to be retained at a temperature between 145° F. and 150° F. for thirty minutes. It is usually of simple design, is easily worked and readily cleansed, while the milk temperature can be closely controlled. In spite of these advantages, the efficiency of the apparatus is not high. Although the bacterial content of the milk is considerably reduced, no guarantee can be given that pathogenic organisms will invariably be destroyed. Convection currents, swirls in milk and variations in velocity prevent adequate heating of all the milk passing through the plant. Commercially the process is useful in that it prolongs the life of milk by reducing its bacterial content. Large quantities of milk can be handled by this method but, as no guarantee of safety can be given, this treatment is not suitable for the production of a designated article.

(3) *Low-temperature Process.* This method of treatment is recognised as suitable for milk which is to be sold under licence as " Pasteurised." While it has lost some of its former pre-eminence following the advent of the high-temperature short-time process, particularly where large quantities of milk have to be handled, the low-temperature process is still widely used by small distributors. Two methods of low-temperature holding treatment are commonly employed :—

(*a*) *" Batch " Pasteurisation.* This method of treatment is suitable for the distributor with a relatively small trade. Properly designed and constructed plants of this type will give uniformly good results, provided they receive sufficient care during operation together with efficient maintenance. The milk is heated, held and often cooled in a single tank. A plant of this type can handle from 50 to 300 gallons of milk per day, according to the number of tanks provided. The original outlay is reasonable, while the plant is economical in operation. The holder proper is a single tank accommodating from 15 to 100 gallons of milk. It is generally cylindrical in shape. The container is surrounded by a jacket, to which the heating medium, either low-pressure steam or hot water, is admitted. The milk is retained for thirty minutes at a temperature between 145° F. and 150° F. Provision is made for some form of insulation so that the milk temperature does not fall during the period of operation. The holder compartment should be designed in such a way as to hold a given quantity of milk and be free from any recesses or pockets which might harbour bacteria. It should permit of easy cleansing and have an adequate heating surface. This ensures rapid heat exchange. Suitable temperature controls must be provided. The milk is agitated during the process to secure uniformity of heating. Such agitation should not be allowed to affect the subsequent rising of the cream after treatment. The temperature of the steam or water in the jacket is higher than that which the milk need attain, but immediately the milk reaches the pasteurising temperature the heating agent is disconnected, the milk remaining at the requisite temperature throughout the holding period. Provision is sometimes made for circulating the heating medium by mechanical means in order that " hot " or " cold " spots can be eliminated and temperatures more efficiently controlled. Milk should be preheated prior to holding. A lengthy waiting period may induce a " cooked " flavour. Cooling may take place after treatment by circulating cold water through the surrounding jacket. This process is slow and is not conducive to low bacterial counts, good flavour or satisfactory cream-line.

Cooling should preferably be carried out in a separate unit, although a primary cooling in the holder may be supplied if desired. No milk should be held outside the heated jacket of the holder. Pumps and pipe-lines used for untreated milk should not be employed for milk after treatment. Such auxiliary apparatus should be washed and sterilised between filling and discharging if dual use is unavoidable. Hand or mechanical filling of the holders may be employed.

(*b*) *Multiple-compartment System.* When large quantities of milk have to be treated daily, the " batch " method is unsatisfactory. This method, which is really an extension of the " batch " system, employs an apparatus provided with several compartments or tanks, which may or may not be housed within a common framework. This type of plant was almost universally installed in the large processing dairies until superseded by the high-temperature short-time process. Normally, this type of apparatus incorporates efficient controls, the operations being fully mechanised to obviate risk of faulty treatment. Continuous action is obtained by the employment of a number of large tanks or holders in such a way as to secure the unchecked outflow of treated milk. The holding period should never exceed thirty minutes. This obviates hold-up at the bottling point owing to shortage of processed milk. The apparatus may vary considerably. One type consists of a set of containers each filled through its own valve from a common supply pipe and discharging either through the same pipe or through a separate pipe into a common main. Treated milk may come into contact with the untreated liquid when this type is used. In modern apparatus inlet and outlet valves are kept apart. By means of the special leakage grooves provided any milk which escapes past the valve falls clear of the system. In another type of apparatus a set of six containers rotates slowly in a clockwise direction in relation to common filling and discharging devices. Alternatively, these latter may revolve while the containers remain stationary. Preheating of the milk is commonly arranged before it enters these compartments. The flow must not be excessive, otherwise danger may arise from milk overflowing from one compartment into another.

The third type of plant is known as the " Individual Tank System," each compartment being a separate tank with capacities up to 1,000 gallons. Common filling and discharging devices are provided. The compartments are usually covered and well insulated against heat losses. With such plant the process will be satisfactory provided (*a*) the milk is delivered to the apparatus at the correct temperature, (*b*) heat losses are properly guarded against, and (*c*) there is no misuse due to failure of the human element. Many large plants of this type employ the *vacuum and compressed air system*, in which the milk, instead of falling by gravity or being pumped, is carried by means of a vacuum to the various compartments and expelled by means of compressed air, the tanks themselves being at atmospheric pressure during processing. A timing mechanism controls the application of both vacuum and compressed air to each tank in turn. The process is independent of valves. Control is simplified, as the entire treatment can be carried out in a close circuit free from air-borne contamination, oxidation or evaporation. When the tanks are filled they are under reduced pressure, so that the escape of any " off " odours is facilitated. The only leakage which can possibly occur is from milk already treated to milk undergoing treatment. The raw milk storage tanks should be placed at a lower level than that of the apparatus to prevent milk flowing into the holders during processing.

Foaming should be prevented in the tanks, as the temperature of the foam may be 8° F. to 12° F. below that of the remainder of the milk. This trouble can be prevented if the milk flows quietly into the tanks from below, or if steam-operated air heaters are fixed in the tanks to warm the air above the surface of the liquid. *Inlet or outlet valves* may be either hand or mechanically operated. Mechanical valves are generally controlled by means of a timing mechanism. Valves call for special attention, as they tend to show signs of wear after prolonged use. Unpasteurised milk should never be allowed to find its way into the treated product. Any leakage from closed valves should be conducted away from the plant. *Agitation* is a commercial necessity and prevents the cream rising to the surface of the liquid. The formation of a membrane is thus prevented. From the public health viewpoint, agitation is necessary in order that all particles of milk may be properly heated. It should be noted that agitation complicates matters as regards cleansing of the holders. If agitation is not properly carried out, exposure of the milk to the atmosphere will be increased, favouring the destruction of vitamins and impairing the flavour of the liquid.

(4) *Pasteurisation in Bottle.* This method is a modification of the low-temperature system and complies with licensing requirements. It has never been very popular in this country. It has been practised in America on a reasonably large scale, although the number of distributors using it has fallen considerably both in America and in this country. Theoretically, pasteurisation in bottle is an ideal method, since milk treated in this manner cannot be contaminated either during or after treatment, or during subsequent operations prior to delivery. The milk is also stated to exhibit better keeping qualities than those imparted by treatment in bulk. The system would be of greater practical use if it could be employed in the pasteurisation of milk at the farm directly after production.

Pasteurisation in bottle may be applied in two ways. Milk may be filled into hot bottles direct from the bottle-washing machine. After sealing, these bottles are submerged in tanks containing water at a temperature slightly above pasteurising level, the time taken to traverse these tanks being thirty minutes. The bottles finally travel through cold-water tanks, for cooling purposes. The method generally adopted in this country is to make use of the hot-air tunnel. Milk at a temperature of 146° F. is filled into hot bottles, which are sealed and crated. The filled bottles in their crates pass through the hot-air chamber, which is maintained at a temperature of 146° F. to 147° F., the time taken to travel through being thirty minutes. Treated bottles are cooled in stages, first by warm and then by mains water, followed by chilled water which cools to 40° F. Efficient temperature controls are essential. Milk pasteurised by this method has a low bacterial content, particularly as regards coliform organisms, exhibits a satisfactory cream-line and has exceptionally good keeping qualities. A rotary plant capable of handling smaller quantities of milk has been designed, while experiments are being made to adapt the short-time process to milk in the bottle.

(5) *High-temperature Short-time Process.* This process has certain commercial and economic advantages, and was adapted from the " flash " and " continuous-flow " processes. The short-time process received official approval in 1941. Many large processing dairies have discontinued the use of low-temperature plants in favour of this method. High-temperature short-time pasteurisation is only permitted provided (*a*) the milk is retained at a temperature of 161° F. for fifteen seconds, (*b*) the apparatus is fitted with full thermostatic control and (*c*) a suitable device is provided to divert the flow of milk which has not been properly held. Various types of holding section, or retarder, are used, plate, tubular and electrical types being employed for this purpose. The milk is preheated, usually in a plate regenerator, and is retained in the holding section for at least fifteen seconds, any sub-temperature milk being returned for further processing by the operation of the flow-diversion valve, the most important part of the apparatus. This valve is controlled by the milk temperature. If the temperature falls below the specified level the valve opens. The flow of milk is then diverted into the raw-milk tank or pipe-line. The provision of adequate and efficient temperature controls is essential. In America, an

electrical method of short-time processing has been evolved, the milk being heated by its resistance to the passage of an electrical current as it passes between two carbon electrodes. The temperature reached is dependent upon the strength of the current and the rate at which the milk flows. The short-time method of treatment represents a scientific process. In view of the smaller margin of safety available, much greater operational precision must be guaranteed than was considered necessary when lower temperatures were used. With this apparatus the distributor is able to treat his milk in a less cumbersome plant at lower capital cost. Working costs are reduced, and the public is provided with a safe milk, always provided the apparatus is properly used and maintained.

(6) *Vacuum Pasteurisation.* In the United States of America a system of vacuum pasteurisation has recently been introduced, its object being to improve the flavour of milk and to ensure effective treatment. It is claimed that the process magnifies the volatilising effect of the normal pasteurisation and cooling processes, in relation to off-flavours, resulting from feeding materials and other influences. In vacuum pasteurisation the milk is treated under pressure, this being immediately followed by a sudden and spontaneous expansion into a finely-divided state within a chamber of reduced pressure. The separation of the treated milk and its contained off-flavours is produced by the sudden transition from a state of compression to a state of expansion, and is maintained by heating the walls of the separating or vacuum chamber. The instantaneous pre-cooling effect upon the product which accompanies its expansion within the vacuum chamber is said to be the important factor in preserving the desirable body characteristics of the liquid, even when unusually high pasteurising temperatures are employed. The process provides for the heat treatment of milk within the conventional pasteurising range, and also at abnormally high temperatures, i.e. above the normal " flash " range and within the sterilisation limits of 200° F. to 250° F., or even higher.

Premises

To provide for the satisfactory heat-treatment of milk suitable premises are required, the housing of the plant being correlated to the design of the apparatus. Adequate initial space is essential, while an allowance should be made for future expansion. Insufficient space is frequently due to lack of adequate care in planning the lay-out rather than to an actual restriction in available accommodation. The principal requirement is a suitable well-planned building. The *walls* should have hard internal surfaces, while a non-slippery *floor* of hard material, well drained and capable of suitable cleansing, should be provided. The *roof* should be free from dust traps and should provide adequate lighting and ventilation. This helps to ensure that there is freedom from noxious odours and effluvia. Adequate *floor space* will facilitate working arrangements, assists in ventilation and prevents difficulties in management, cleansing and inspection. Apparatus should not be placed in too close proximity to walls. Suitable *ventilation* and sufficient *air space* are prime factors, bearing in mind the high degree of atmospheric humidity invariably found in premises in which steam is used. Excessive moisture produces uncomfortable working conditions and condenses on ceilings, whence it drops on to apparatus and even into the milk. *Controlled air conditioning* is the ideal system. This will maintain suitable temperatures in all weathers, restrict humidity, provide adequate ventilation and assist in maintaining cleanly conditions. A pure and adequate *supply of water* of suitable softness is essential, together with suitable *natural and artificial lighting*. Good lighting assists in the maintenance of hygienic conditions, while accidents to employees are correspondingly reduced. Adequate *toilet facilities* should be provided for the personnel, with washing accommodation, hot and cold water, soap and towels. The staff must be instructed in their frequent use. Toilets should not open directly into any processing room, an intervening ventilated space being required. Fly screens should be provided, while doors should be self-closing.

Essentials of Plant Design and Operation

The treatment of milk must be rigidly controlled with the correct temperature and time limits specified. The liquid must be heated once only, and must be cooled as rapidly as possible after treatment. During the preheating and holding periods the milk must be protected from contact with the atmosphere. The same protection should be afforded while the liquid is being cooled. Milk should preferably be aerated during receiving and cooling, if this can be achieved without fear of contamination. Pumping should be reduced to a minimum. If pumping must take place, it should be carried out when the milk is warm. Pipe-lines should be as short as possible to prevent unnecessary pumping. After cooling, agitation of the milk should be reduced to a minimum. Any short-circuits in the process should be carefully avoided to prevent " unheld " milk gaining access to " held " milk, i.e. there should be no forward leakage. There should equally be no backward leakage, otherwise some of the milk may receive excessive treatment. In this connection it must always be borne in mind that one drop of infected milk may affect the entire volume. Plant should be designed to facilitate cleansing and sterilisation. Corners and angles in tanks should be avoided ; bends should be given as large a radius as possible to avoid providing harbourage for dirt or bacteria and to prevent the accumulation of " milkstone." All parts of the apparatus should be fabricated of the highest-quality metal ; permanent joints and seams should be assured by means of autogenous welding, the use of solder encouraging electro-chemical action. The provision of reliable temperature-indicating *and* recording instruments, constructed to show a variation of ±0·5° F., is essential. The plant should operate automatically, milk being untouched by hand from beginning to end of the operation. This requirement applies principally to the larger processing plants. Apparatus should be adequate in size to treat all milk passing through without the need for speeding up the tempo to the detriment of the final product. Possible expansion of business should receive careful consideration before any decision is arrived at regarding plant capacity. The entire equipment should be adequately co-ordinated and should not merely represent an assortment of varying pieces of apparatus. Thus the plant must be envisaged as a single unit, the choice and arrangement of the component parts conforming to this principle. In short, the plant should be inexpensive to maintain, reliable, efficient, simple in construction and compact. It should be constructed of durable materials, easily operated and kept clean, and should be continuous in action.

Pasteurisation Problems

The ability of milk to be pasteurised is important. It was at one time thought that any low-grade milk could be successfully pasteurised, particularly as the life of such milk was increased by this treatment. It has now been realised that this is not the case and that clean milk is essential for efficient treatment. When the bacterial content of milk is high, deterioration occurs. These changes cannot be neutralised by pasteurisation. Any taints present in the original unclean raw milk may remain after processing, and thereby lower the commercial value of the product. Unclean milk contains both *thermophilic* (heat-loving) and *thermoduric* (heat-resistant) *organisms.* These organisms are often present either in large or small numbers in pasteurising plants. Thermophilic organisms have no public health significance but are troublesome to plant operators, causing spoilage of the product. Thermoduric organisms may be present in large numbers in the raw milk supplies arriving at the plant for treatment. Unsatisfactory methods of milk production and handling are then indicated. The *mechanical effects of pasteurisation* exerted by pumping or agitation during holding are important. To preserve an adequate cream-line—a commercial necessity—cold milk should be pumped or agitated as little as possible. Care should also be taken to ensure that the milk is never violently agitated or pumped after treatment or following cooling, as the cream-line may be reduced by as much as 10 per cent. by this means. *Metal surfaces* are often overlooked. The essential feature of a good metal for dairy purposes is that it should possess a smooth surface which can be easily cleansed and scoured. Metallic contamination of the milk should be impossible, while the metal must be a good conductor of heat, resistant to corrosion and be easily and cheaply fabricated. Stainless steel, monel metal and chrome nickel steel are suitable for plant fabrication. Glass-enamelled metals are also satisfactory. These are easily cleansed, although their surfaces can be readily chipped or scratched if adequate care is not taken. Accurate *temperature control* is an absolute necessity during processing, whatever methods are employed. The provision of suitable *indicating thermometers* and at least one *recording thermometer* should be insisted upon. *Charts* should be on a suitably large scale. All temperature-indicating and controlling apparatus should be maintained in proper working order at all times.

Pasteurising Plant

The complete pasteurising plant has a number of component parts, all of which call for consideration. *Tipping tanks* are to be found in most dairies for the receipt of incoming milk. These should be constructed of suitable metals such as stainless steel, which will resist the corrosive action of milk and can be readily cleansed. They should be provided with suitable covers to prevent air-borne contamination. *Pumps* are often necessary and can produce gross contamination if improperly cleansed. No glands or stuffing boxes should come into contact with the milk. Stainless steel or some similar metal should be used for the construction of their internal surfaces. *Storage tanks* are generally required. The incoming milk is stored in such tanks until required for processing. Storage tanks should be kept covered and be easily cleansed, means of access being provided for the purpose. *Balancing tanks*, if provided, should be covered at all times. *Heaters* are required to raise the milk temperature to pasteurisation level. Several types are employed. They may be designed in the form of a surface cooler, with milk distributed over their outer surfaces, and the hot water used as the heating agent internally, or they may take the form of a " flash " pasteuriser. Alternatively, tubular heaters may be used. Generally speaking, the preheater makes use of regeneration, both heating and cooling the milk, the cold milk which enters the plant being heated by the treated milk as it leaves the pasteurising section. Both plate and tubular heaters are used for this purpose. All plates and tubes should be capable of easy dismantling for cleansing purposes. To be satisfactory, all milk should be raised to a temperature slightly above that required for treatment. There should be complete separation of the raw from the treated milk and also from the heating agent, while easy cleansing and sterilisation of the apparatus should be facilitated. *Filters* and *clarifiers* are employed to remove any dirt or slime which may be present in the milk. A cloth filter of the closed type is to be recommended for this purpose, as there is then no risk of air-borne contamination. Filter cloths and other filtration media should be frequently changed during processing operations and should be used only once. The accurate working of the *holders* or holding sections is important. Time and temperature must be strictly observed. The various compartments or tubes should be capable of being easily cleansed and sterilised. Air heaters should be installed in the holding compartments of low-temperature plants to prevent surface cooling of the milk, while some form of agitation is desirable. The compartments or sections should be effectively insulated against heat losses ; here temperature control is of vital importance. While the open type of *cooler* will provide a more satisfactory cream-line, an enclosed apparatus on the lines of the heat-exchanger is more satisfactory from the public health point of view because of the liability of processed milk to re-contamination. *Pipe-lines* should be kept as short as possible, should not have any " cold pockets " or " dead ends," and should be capable of being readily dismantled for cleansing and sterilisation. On leaving the cooler, milk passes to the *bottle-filling and capping machine*. These operations should be carried out with a minimum disturbance to the liquid, and with an absence of foaming. On no account should milk be pumped from the cooling section to the bottling machine. The balancing tank over the bottling machine should be kept covered at all times. Bottle conveyors should be provided with shields.

A *bottle-washing apparatus* is necessary where a large number of bottles have to be cleansed. Various methods of treatment are given by means of hot and cold water rinses, detergent rinses of varying strengths and temperatures, and final clean rinses or steaming. Great care is necessary when dealing with milk bottles. Many such bottles are in a dirty condition when returned. It is important to remember that the milk bottle is the only utensil which leaves the dairyman's control and which may become grossly polluted in the home of the consumer. During the washing process care must be taken to maintain detergent strengths and control the temperatures of the various solutions and rinses. Detergent solutions are often diluted for economic reasons or through carelessness. *Churn washers* are also employed. Here, again, time and temperature with the maintenance of the correct detergent strength are important. *Non-returnable cartons* have been used. Although these form an ideal means for delivering milk, they have never been popular. Bottles should be sealed by caps which cover the lip of the neck. Metal foil must be employed for this purpose if the milk is sold under the designation " Pasteurised."

Cleansing Operations

The cleansing of plant should be regarded as a major operation. Apparatus may be quickly ruined and the treated product rendered unsatisfactory if proper methods are not employed. Temperature differences between the heating medium and the milk, together with failure to cool speedily and wash equipment thoroughly after use, causes milk solids to be burnt on to the metal surfaces. The bacterial content of the milk subsequently treated may be so high as to render processing a waste of time and expense. Cold milk leaves the equipment greasy ; hot milk throws up a deposit of milkstone consisting of the milk salts impregnated with organic matter. This milkstone harbours large numbers of bacteria. All apparatus should be cleansed as soon as processing has ended, cold or tepid water being passed through the plant. This treatment should be repeated with hot water containing a suitable detergent. The volume of water used should be sufficient to ensure that all liquid milk is washed from the apparatus and the pipe-lines. The interior of tanks and the surfaces of open coolers should be well scrubbed. All parts of the plant should then be dismantled and well scrubbed with hot water and detergent, followed by washing with clean hot water. All pipe-line sections and small parts should be similarly treated, after which they should be sterilised with steam and stored in a clean place. Filters, heat-exchangers, holders and receiving and storage tanks should be well scrubbed, care being taken to remove all milkstone during the process.

The cooling sections of the plant should receive particular attention, as any lack of sterility at this point will result in re-contamination of the treated milk. The plant should finally be re-assembled. Before the commencement of the next run all sections should be flushed through with warm water containing sodium hypochlorite to give the plant a preliminary warming and to ensure complete sterility. By exercising the greatest care during cleansing operations the bacterial content of the product will be materially decreased and the value of the treated milk greatly improved. Many of the unsatisfactory results obtained from well-designed plants are actually the result of carelessness in cleansing operations.

Plant Inspection

While considerable attention has been paid to pasteurisation and other forms of heat treatment from the point of view of the safety of the product and from the nutritional standpoint, the technical aspects of milk processing have not received sufficient attention. The inspecting official should have a thorough knowledge of the processes employed. Plant operators and personnel should appreciate the scientific principles involved in milk processing. Indeed, no one should be intimately concerned with heat treatment methods unless he or she holds a certificate of competency. While the larger firms are aware of their responsibilities in this respect, sufficient understanding of the essentials of efficient processing is not always found among smaller distributors. Such individuals most often look to the inspecting official for guidance.

Lack of efficiency and care have produced endless difficulties in the past and have provided arguments used in criticism of pasteurisation. Carelessness is not generally wilful and may not be the fault of the plant operator or his employees. The apparatus employed is often far from satisfactory, attempts at combining different types of plant having led to insurmountable difficulties. A further point not sufficiently realised is the ease with which properly-treated milk can be re-contaminated. Too much milk is at present being processed with the sole object of improving its keeping qualities, without any thought being given to the public health issues involved.

Stricter control is indicated if processing is to be efficient and the consumer enabled to rely upon the final product.

The *building* in which the plant is housed should receive initial consideration. Particular attention should be paid to general cleanliness, while the condition of walls, floor and roof, ventilation, air space and lighting, together with freedom from dust and effluvia, should also be investigated. Economy of space in the *lay-out* should be noted, although there should be no overcrowding of the apparatus. Any allowance should have been made for future expansion of the plant. Sufficient space should be available for proper operation and cleansing. Operations should be carried out in a suitable light, the latter point being particularly important so far as temperature-control instruments are concerned.

The following points should receive careful attention during inspection of the *plant* itself. *Tipping tanks* should be clean and protected from dust and oil droppings. *Pumps* should operate in such a way as to obviate foaming and frothiness. The cleanliness of the *heaters* is important. Suitable temperature controls should be provided and there should be complete separation of the incoming milk from the heating agent and the pasteurised product. *Filters* should be clean and their cloths changed frequently ; excessive filtration pressures should not be used. The *holding compartments or sections* should be clean and well insulated, the milk being protected at all times from contamination. Foaming should again be avoided. *Valve efficiency* should be checked, this being particularly essential when a flow-diversion valve is employed. The accuracy of valve timing is important. Milk should always be maintained at the correct temperature ; there should be no overflow of milk from compartment to compartment. Efficient temperature control is essential at this point. The *cooler* should be clean and protected from dust, with complete separation of the milk from the cooling medium. Separate *pipe-lines* should be provided for the raw and treated milks. These should be clean, free from angles and sharp bends and capable of rapid dismantling. All *storage tanks* should be perfectly clean ; any agitating gear installed should be readily dismantled. Separate tanks should be provided for the raw and processed milks. There should be no drips from the valves of *bottle-filling machines*. The milk reservoir should be covered ; this portion of the apparatus and the adjoining capping apparatus should be maintained in a scrupulously clean condition. Inspection of the *bottle-washing machines* should be directed towards cleanliness of the jets, maintenance of suitable water and detergent temperatures, detergent strength and its method of maintenance. *Utensils and bottles* should be perfectly clean. Clean storage after sterilisation should be available.

Apart from the plant itself, various additional points require investigation. The bacterial quality of the incoming milk is important, although often overlooked. Maintenance of milk temperature, regulation of the holding time, insulation of holders and absence of forward leakage of milk are all important and should invariably be investigated. No milk should lie outside the holding zone during treatment. Enquiries should be made as to the method used to determine the temperature of the milk during pasteurisation. Protection from contamination during cooling and bottling, together with the cleanliness of the empty bottles, should be investigated, as should the methods of plant cleansing and sterilisation. The bacteriological content of washed bottles when ready for filling should not exceed 200 organisms per bottle. Methods of churn washing also demand investigation. The washed churn should be clean and dry, with a bacterial content not exceeding 50,000 organisms per churn and preferably less. Swab tests of plant surfaces should be made to assess the value of the methods employed in cleansing. There should be no dripping of condensed water from damp ceilings, no sweating or leaking overhead pipes and no leaks from milk and water pipe-lines due to damaged joints. Flies should be absent, while the water supply, particularly when obtained from a private source, should be frequently examined for bacteriological purity. The health of the personnel should be investigated. Early signs of ill health can then be assessed and adequate treatment indicated.

Particular attention should be paid to temperature control. Indicating and recording thermometers should be suitably tested against a standard thermometer. Frequent tests of the holding period by means of one of the chemical tests available should be made in the case of high-temperature short-time plants. The flow-diversion valve should be examined and tested to ensure proper working. The product should be subject to frequent *bacteriological and chemical tests*, use being made of the methylene-blue test as regards keeping quality, and of the phosphatase test in relation to efficiency of treatment. Line samples of milk taken at various points in the plant should be examined. Swab samples of equipment should also be taken at frequent intervals to check treatment of the milk, together with methods of cleansing and sterilisation. Total bacterial counts plus coliform estimations are also useful. The total bacterial count supplies evidence of plant contamination ; coliform estimations will reveal post-pasteurisation contamination. The *physical examination* of pasteurised milk should be concerned with taste, temperature and appearance. The sediment test can be applied if desired. Temperature records should be inspected at frequent intervals. Plant inspections should not be confined to weekdays, but should be made on Sundays and public holidays. These latter inspections will speedily repay the extra time entailed, providing as they do a valuable check on personnel who may have neglected certain duties in their haste to finish work.

Composition

The *efficient* treatment of milk by the pasteurisation process does not produce any appreciable change in composition. The butter-fat, lactose, proteins and mineral content are not seriously varied, although certain minor changes do occur. The dissolved gases in milk, e.g. carbon dioxide and oxygen, are lost when the liquid is heated, while certain of the vitamins are affected to a greater or lesser degree. The solubility of the mineral content is slightly reduced, minute traces of ammonia being found in the treated milk. Generally speaking, the enzymes are either destroyed or inactivated, while the condition of the proteins is changed. The changes which occur vary in accordance with the method of treatment employed and the manner in which the selected treatment is carried out. As improvements in the technique of pasteurisation are made, alterations in composition should be still further reduced.

Nutritive Value

In spite of criticisms so often expressed against pasteurisation in relation to the nutritive value of the milk so treated, the changes which occur are negligible. Experiments carried out by Kon and his associates have shown inferior product will result. It is a legal requirement that unsold ice-cream should be re-processed before being again frozen.

The *hardening process* may take place either before or after packing. This procedure is important, as the fine texture of the ice-cream as it leaves the freezer may be destroyed by improper hardening. The frozen cream is stored at temperatures between 0° F. and − 30° F. for six to twenty-four hours, such temperatures being necessary to ensure quick hardening and to maintain the overrun. If the contained air in the cream is allowed to leak from the product the bulk will be considerably diminished. Hardening or refrigerated rooms are used for this purpose, the product being stored on shelves composed of piping carrying the refrigerant. "Tunnel," or continuous hardening is sometimes employed.

Packing takes place either before or after hardening. A very high overrun is neither necessary nor desirable in packaged ice-cream, as none of the added air is lost as is the case when ice-cream is served in portions. If hardening takes place after packing, the cream is run from the freezer into moulds for hardening prior to splitting and cutting into bricks. The ice-cream may also be run into 2- or 4-gallon cans, or into cups or tubs. The product should not be too hard if it is to be filled into containers of this type, otherwise filling will be difficult and the containers will be imperfectly loaded. Many varieties of ice-cream bricks are now wrapped in parchment paper, some being covered with chocolate. Because of this the hygienic quality of the wrapping paper is important. Only the highest-quality paper should be utilised for this purpose.

Storage and distribution are important. Improperly stored ice-cream tends to separate into its original constituents. The watery element freezes into sharp ice particles, the product appearing gritty to the palate. Constant storage temperatures are therefore essential. In the refrigerated shop cabinet lengthy storage causes shrinkage, due to the escape of air incorporated as overrun. Transport in cans has now been largely superseded by non-returnable cardboard packages, whose inside surfaces should be finished with white wax. When sealed, such packages are strong, airtight and hygienic. Little time is required to assemble these packages, while the cleansing of returned cans is avoided. Solid carbon dioxide is widely used as a refrigerant during transport and sale. This substance is light, produces no liquid on melting, is easy to handle and has been used for "take home" packages with considerable success. One gallon of ice-cream can be maintained in good condition for twenty-four hours with 2 lb. of carbon dioxide. Attempts have been made to produce eutectic "inserts" from ice and salt. Those so far employed are heavy, difficult to handle and produce liquid on melting. For these reasons they cannot be recommended. Conservators of various types are used for counter storage and sale, employing a variety of refrigerants. They operate economically and can be used for prolonged periods with little or no attention beyond periodical servicing.

As the result of the use of a cold mix, *counter freezers* have become very popular. Freezing takes place in one compartment, the product being then removed to an adjoining compartment for storage and service. The packaging of ice-cream in cups and bricks is rapidly replacing distribution in bulk. From the hygienic point of view this is a step in the right direction. Factory-packed ice-cream can be produced under much more sanitary conditions than is the case in the majority of retail shops. Direct distribution of the product by means of tricycles and vans has largely influenced the development of the small package. It is important to note that the Ice-cream (Heat Treatment) Regulations, 1947, require that, once frozen, no ice-cream shall be sold or offered for sale unless it has been continuously stored at a temperature not exceeding 28° F. Should the temperature rise above this level the product must be re-processed, cooled and stored within the temperature limited set out in the regulations. For bulk ice-cream, the ideal serving temperature appears to be 10° F. If served too cold, the substance will deaden the palate, have little flavour and will be difficult to serve. If served at too high a temperature, it will melt rapidly and will be inclined to have a sweet and even a sickly taste.

Premises and Plant

Premises used for the manufacture of ice-cream should be hygienic in every respect and should be maintained in a satisfactory condition. Lack of sufficient light is a common fault with such premises. This defect not only affects the health of the employees but tends to prevent the maintenance of the premises in a scrupulously clean condition, since dirt cannot be easily detected. Lack of suitable ventilation also reacts upon the health of the employees, preventing the escape of steam and other odours from the processing rooms. The raw materials should be protected from contamination. Suitable accommodation for the storage of such substances and also for the storage of waste matters must therefore be provided. Many premises lack an adequate pure water supply. This hinders thorough cleansing of the plant, the utensils and frequent washing of the employees' hands. It is often found that premises have not been properly planned, many old buildings, sketchily adapted for processing, being still in use. The siting of the apparatus concerned should ensure easy cleansing. There should be no overcrowding of plant. Corners and dark spots where dirt may accumulate should be avoided.

Walls and ceilings should be constructed of smooth, hard and non-absorbent materials, and should be free from crevices and angle joints. Glazed bricks or tiles are admirably suited to this purpose. Floors of tiles or concrete are essential. Wooden floors should not be countenanced. The crevices between the boards of such floors allow dirt to accumulate, while the wooden surfaces are easily indented, so that cleansing is hindered. Constant cleansing renders the wood soft, when the flooring will absorb a considerable quantity of moisture and filth. All angles between walls and floors should be rounded. Floors should be laid with a sufficient fall for drainage purposes. Tiled floors are especially desirable, since they readily reveal any lack of cleanliness. Whatever type of floor is provided, a non-slip finish is essential. Drainage should be adequate. Ventilation should be sufficient to remove all steam and other vapours from the premises, damp air encouraging the growth of moulds and fungi. The various rooms in use should be suitably provided with natural and artificial lighting. Rubbish should be frequently moved to the outside of the premises, the containers being disinfected after use. The interior fittings of the building are important. Shelves should be fitted on stands away from the walls or fixed by means of iron brackets, metal racks being preferable to wooden shelves. Where tables are required, these should be provided with impervious metal tops. Wooden-topped tables should not be employed, as this material readily absorbs moisture and can never be rendered sterile. When plant is inspected, a careful note should be made of the conditions existing in the tion reduces the assimilation of the bone- and tissue-building salts, destroys the vitamins and entirely eliminates the lactic-acid organisms. It must be remembered, however, that, in spite of its reduced nutritive value, sterilised milk is a safe product from the public health viewpoint.

Milk which is to be sterilised is first filtered or clarified, and is then preheated to render it less viscous and to assist in its passage through the homogeniser. After homogenisation the hot milk is filled into sterilised bottles of the special narrow-necked type. Various methods of treatment are then applied. The bottles, already crated with the stoppers loose, may be placed in a steam chest, where they remain at a temperature of 212° F. for twenty-five minutes. In some cases they are treated under pressure at temperatures between 222° F. and 226° F. for a sufficient length of time to destroy the bacterial content. Continuous sterilisers are often employed. Apparatus of this type can deal with between 300 and 1,000 gallons of milk per hour. Their action is automatic, the filled hot bottles travelling in carriers through a hot-water tank and into a central compartment in which steam pressure is maintained for the thirty minutes during which the bottles are passing through. The bottles then pass through a second hot-water tank into the cooling section, meeting a gradually-cooling stream of water as they move forwards. Additional water-spray or air cooling is sometimes employed.

No refrigeration is called for, as sterilised milk is virtually free from bacteria. During the cooling process the external surfaces of the bottles are thoroughly washed and automatically dried. If milk is sterilised under pressure, the final product should be sterile. Some processing methods permit the spores of certain organisms to remain unharmed, with the subsequent production of acid and gas which may render the milk unmarketable. Because of this, clean raw milk is just as essential in sterilisation as it is in any other form of heat treatment. During processing the milk sugar is subject to caramelisation, due to the high temperatures employed. Caramelisation produces a yellowish-brown colour in the treated milk. A bitter taste may also develop due to breakdown of the contained proteins. The bacterial content of sterilised milk when it leaves the plant should at no time exceed ten organisms per millilitre. A turbidity test is employed to determine the efficiency of the sterilisation process. The distributor cannot always sterilise milk efficiently unless he can obtain supplies already clarified and homogenised. The apparatus necessary to carry out the complete process is expensive and cannot profitably be installed in small dairies. Sterilised milk, as a result of homogenisation, has no cream-line and is sold at a slightly higher price than other varieties of milk.

Stassanisation

This process is a high-temperature short-time method of treatment named after its inventor, Dr. Stassano, an Italian member of the Pasteur Institute in Paris. It is a modification of the " flash " method of treatment. While it would appear that certain modifications might enable this method to be used for the pasteurisation of milk, sufficient evidence is not yet available to decide whether or not this is the case.

The modern stassaniser is a compact apparatus, which is combined with a plate heat-exchanger and cooler. The process takes place in a completely closed tube in which the milk is distributed in thin layers without access to air, each layer being approximately $\frac{1}{25}$ inch in thickness. The milk is rapidly heated on both sides of the layer under slight pressure, and in such a way that it is unable to lose its carbonic acid gas content. The temperature attained is 165° F., the milk being in contact with the heating surface for fifteen to sixteen seconds. This rapid heating is followed by a speedy cooling to a temperature of 58° F. or below. Water at a temperature of 166·8° F. is used as the heating agent. Double tubes are employed, the milk passing through an opening of 1 to 1·25 mm. between the inner and outer tubes, which are surrounded by the heating agent, a pump being employed to pass the milk through the apparatus. Adequate temperature controls are provided. The tubes, which are constructed of stainless steel, can be readily cleansed, each tube being just over one yard in length. Cleansing operations are commenced by pumping clean cold or tepid water through the plant until the water emerges from the cooling section free from any traces of milk. A weak soda solution or other detergent is then circulated several times through the pipes, followed by very hot water. Steam is finally blown through for sterilisation purposes, although hypochlorite solutions may be employed if desired. When the end pieces of the tubes are opened, the inner tubes can be extracted for brushing with the special brush provided. The plant is said to be most economical in the use of steam, water and brine.

The commercial advantages claimed for stassanisation are : (*a*) there is no loss of milk through evaporation, (*b*) working expenses are kept at a minimum, and (*c*) there are no losses through milk of decreased value being returned to the dairy. There is no difference in the flavour, odour or appearance of the milk after treatment, while the cream-line is not materially affected. From the public health point of view, milk treated in this manner keeps sweet for at least forty-eight hours and does not possess a disagreeable taste at the end of that period. Curdling is not influenced, while the digestibility of the proteins is retained. The vitamins are only slightly affected. Almost all the non-pathogenic organisms, all the coliform bacilli and pathogenic bacteria are destroyed.

Irradiation

By means of a very short exposure of a thin film of milk to the rays of a mercury-vapour lamp or other reliable source of ultra-violet light the food value of milk may be increased without diminishing the nutritive values present. Research workers have demonstrated that milk develops antirachitic properties when exposed to ultra-violet irradiation by increasing the vitamin-D content. Such milk, when consumed in customary quantities, affords protection against rickets in infants and dental decay in adults. The substance ergosterol is present in fats. By means of irradiation this substance can be converted into vitamin D. Ergosterol is present in the fat underlying the skin both of animals and human beings. By the action of ultra-violet rays ergosterol is converted into vitamin D, which passes into the animal's milk. Dr. G. C. Supplee, of the Dry Milk Company of America, has carried out considerable research into the direct irradiation of milk. He demonstrated that a measurable vitamin-D potency can be generated in milk in proportion to the energy input. He also proved that a thin film of milk which received a short exposure to ultra-violet rays acquired a substantial quantity of vitamin D, and that processing did not produce off-flavours in the liquid or damage the existing vitamin-A content. He further states that the irradiation of milk exerts a bactericidal effect.

Various systems, such as the Scholl, Scheidt, Cherry-Burrell and that designed by the Creamery Package Company (an adaptation of the Steenbock process), are employed. In all of these the milk is irradiated for between five and six seconds as it passes in front of a mercury-vapour lamp in a thin stream, approximately $\frac{1}{3}$ millimetre in thickness. As the short waves are quickly absorbed, the correct distance of the milk from the source of the rays is important. After treatment, irradiated milk usually contains 135 U.S.P. units per quart. If this amount is exceeded the flavour is impaired. Over-exposure of the milk to the action of ultra-violet rays leads to oxidation of the contained fat globules, this action being completed in eleven seconds. A taint will result if care is not exercised. Milk may be treated either in its raw state or after pasteurisation, preferably the latter. Irradiated milk does not lose its potency during storage or other subsequent treatment. The process is controlled by means of strict patent rights. Condensed and evaporated milks are often treated in this manner to increase their vitamin-D content.

The rooms in which irradiation apparatus is housed demand special consideration. The air used for ventilation purposes should be drawn through dust filters. The rooms should preferably be air conditioned ; fans should be provided to remove products of combustion from the lamps together with any ozone which is produced. Eye protection for the operators is essential, constant exposure to the rays leading to conjunctivitis. The rooms should preferably be provided with special windows of darkened glass so that the operator can observe processing without direct exposure to the lamp rays.

The bacterial content of milk treated by irradiation is appreciably reduced. As already stated, the vitamin D content of the milk is greatly increased, while experiments have shown that the vitamin D present in irradiated milk is much more active than that found in cod- or halibut-liver oils. If the process is properly carried out the taste of the milk will not be altered. The cream-line is unaffected, while the food value of the liquid is not impaired in any way. The process has not proved popular in this country, although in Canada and America sales are steadily increasing.

CHAPTER XIII

ICE-CREAM

ICE-CREAM, looked upon as a luxury not so many years ago, is now almost universally regarded as a staple item of every-day diet. The fact that ice-cream formed part of the daily rations of the United States service man stationed in this country during the War had much to do with this change of opinion. Apart from its food value, the production of ice-cream forms a useful outlet for surplus milk and surplus dairy products. After a ban on production which lasted for several years, ice-cream now enjoys a ready sale among all sections of the community. It still remains a fact, however, that much low-grade ice-cream is sold at the present time at a price far in excess of its food value. Still greater sales are likely to follow when the public realises that the best ice-cream is scientifically prepared under proper hygienic conditions comparable to those which apply to the manufacture of other good-quality foodstuffs.

As long ago as the reign of Charles I ice-cream was eaten as a dainty or luxury, having been introduced into this country from France. Carlo Gatti, an Italian, first manufactured ice-cream for sale to the public in 1860, the substance consisting of milk and egg custard manufactured in a hand freezer. His business prospered to such an extent that he soon brought over from Italy his relations and compatriots, who assisted him in the ever-expanding retail business. Plain ice-cream bricks, without wafers, horns or cornets, were first sold ; eventually wafer biscuits were used to cover the bricks. The ice-cream trade remained chiefly in Italian hands until after the war of 1914–18, when machinery was imported from America to produce ice-cream on an extensive scale. With the continued increase in the quantity sold there has been a steady improvement in the plant used for manufacturing purposes. The conditions under which ice-cream is produced have undergone considerable improvement, particularly in relation to the larger firms concerned in its manufacture. These firms have ousted many small producers, who had neither the ability nor the capital to carry on the production of this foodstuff in a proper and efficient manner. Many small dealers do still exist, not all of them satisfactory, but they are likely to be eventually driven out of business by economic pressure, due to the demand for better premises and methods.

Ingredients

Whatever ingredients are used in the manufacture of ice-cream, they should, as in all foods, be of the highest quality. Restrictions in force at the present time prevent the use of many pre-war ingredients. The paragraphs which follow should be read with this in mind, as eventually the days of shortages will end and normal conditions render available all those constituents now lacking even in the best-quality ice-cream.

Home-made ice-cream usually consists of milk, sugar and eggs in the form of a frozen custard. The ice-cream manufactured by small dealers is generally produced from ice-cream powders, or it may contain milk in one of its many forms, sugar, custard powder and either whole or dried eggs. A small quantity of dried egg imparts smoothness to the product, improves the whipping quality of the mix, ensures a speedy overrun and improves the food value of the mixture. The final product is more resistant to melting at room temperatures. Considerable use is also made of cereal fillers in the form of ice-cream powders, many of which contain soya flour. Gelatine and other stabilisers are often added to provide consistency. Gelatine should always be of the highest quality, otherwise it may be a fertile source of bacterial contamination. This material is useful in that it prevents the gradual crystallisation of the ice-cream during storage. Other gums are sometimes employed but may be most undesirable. Pectin added to the mix will improve the body of the product. This substance should preferably be used in combination with gelatine. Excessive quantities of stabiliser lower the quality and affect the taste of the ice-cream.

Modern large-scale production bases its mix formulæ upon the percentage content of the ingredients, which may include butter-fat, serum solids, sucrose and corn sugar, dried eggs and some type of stabiliser. The butter-fat may be provided by the addition of milk or cream, by the use of plastic cream or butter, by the admixture of condensed or evaporated milk or full-cream milk powders. This type of mix is admirably suited for manufacture in the modern freezer. It affords an opportunity for compounding the mix from a variety of dairy products, flavourings being added as desired. The fat content of dairy ice-cream is introduced either in the form of cream or by the use of unsalted butter incorporated in the mix, the remaining milk solids being in the form of condensed milk or skimmed-milk powder. The total solids content is usually high, generally in the region of 33 to 35 per cent. This gives the desired texture. *Stabilisers* or protective colloids are employed to provide a smoother texture or body, not only in the freshly-frozen ice-cream but also during the time the product is stored in the dealer's cabinet. A good stabiliser prevents coarseness during storage, should be convenient to use and should not hinder the normal processing or freezing of the mix. It should not be noticeable when the ice-cream is eaten. Gelatine is best added to the mix before it is pasteurised to retard bacterial growth. Vegetable stabilisers, such as starches, gums and sodium alginate, are also used. Starches, often added to low-grade ice-cream in the form of powders, swell and absorb large quantities of water so that a smooth cream results. These powders usually consist of cornflour or a combination of starches, egg powder, stabiliser, flavouring and colouring materials. Gum will act in a similar manner but renders homogenisation difficult, as the milk is likely to be stringy while the body and texture of the finished article may be "soggy." Sodium alginate is often employed in the place of gelatine as a stabiliser. While sodium alginate is correctly classed as a gum, its action is somewhat different to other gums in that it will not cause undesirable properties to develop in the mix, although absorbing large quantities of water. When sodium alginate is used, the viscosity of the mix is increased, while there is no filmy after-taste in the mouth. Faster whipping is also possible.

The quantity of sugar added is governed by the fat content. It has been found in practice that a high fat content and a high sugar percentage do not combine well. Dextrose, often used to replace cane sugar, is more effectively sweet than the sugar it replaces. The total solids content should be fixed to prevent ice particles being formed and to avoid a heavy "stodgy" product. Any cream or milk used in the mix should not have an acidity of more than 0·15 per cent., preferably less. Cream is usually aged in a cold room for twelve to twenty-four hours in order to develop its whipping properties. In some instances a small quantity of salt is added to the cream to enrich its flavour. This practice is not to be recommended. Starch or cereal fillers are not necessary in a rich mixture, but are often added to cheapen the product by providing bulk or to give body to what might otherwise be a poor article.

Ice-cream as at present retailed has a much lower fat content than was formerly the case. Cereal products are extensively used to supplement such milk solids as may be used. Cereal fillers will no doubt retain their popularity because of cheapness, the probability being that certain manufacturers will continue to employ them until legislation prevents their further use. It must be emphasied that milk products cannot at present be included in ice-cream, although skimmed-milk powder may be incorporated in the mix. Glucose chips, which have approximately three-quarters of the sweetening value of cane sugar, are often used. Sugar, skimmed-milk powder and a small quantity of margarine or other animal or vegetable fat are the only pre-war ingredients now allocated to the trade.

Manufacturing Methods

The methods employed for the manufacture of ice-cream fall into two distinct categories. The *small vendor* employs the simplest materials and methods in the manufacture of his product. The majority of outbreaks of infectious disease traced to the consumption of ice-cream have arisen from the product manufactured by this class of vendor. Many small vendors are almost completely ignorant of the simplest methods of hygienic food production ; others are neither conscientious nor even scrupulous in the conduct of their business.

The ingredients in common use have already been indicated. The starchy materials are mixed into a smooth paste. The liquid is then added and the whole is warmed. The sugar and flavouring materials are added during the heating process, constant stirring being necessary to prevent scorching. When boiling point has been reached the mix is allowed to simmer for a few minutes, after which it is strained through a cloth and allowed to stand over-night. Slow cooling favours bacterial development and is not to be recommended. This was formerly a common practice among small vendors, who were not required until recently to cool their mix rapidly. The mix is frozen on the following day, usually in a hand-operated freezer, the freezing agent being a mixture of ice and salt. Alternatively, the mix may be poured on to a revolving drum which contains a freezing mixture. The mix is removed in a frozen condition by means of a metal blade or scraper and falls into a container. Difficulties in cleansing have to be overcome. Many high bacterial counts are due to difficulties in this field. Sterilisation of the apparatus is not easy. Although cleansing by means of boiling detergent solution is recommended, difficulties in maintaining the solution temperatures during use have to be faced.

The methods of manufacture outlined above afford countless opportunities for bacterial contamination. When milk is used, the bacterial content may be high, while the absence of any attempt to pasteurise the mix will facilitate the development of the original organisms present. Low-grade or cheap materials used in manufacture furnish another potent source of contamination. The annatto sometimes employed to enrich the final colour is often of questionable purity. Utensils represent an additional and fertile source of danger. Dirty pans and equipment, inadequately washed, unsterilised and stored in all manner of unsatisfactory places, are still to be found. The domestic washing copper is sometimes used for preparation of the mix, the product being almost invariably allowed to cool in uncovered containers very often in kitchens open to both atmospheric and other incidental pollution. It is little wonder that a product manufactured in this manner has often been responsible for spreading disease. Although such careless methods are by no means unusual, they are not universal among small vendors. It should also be noted that large manufacturers cannot always be absolved from blame.

When *large-scale manufacture* of ice-cream is practised, methods are normally more hygienic. Consideration should first be given to *raw materials*. These must be of the highest quality if the resultant product is to be satisfactory in every respect. Apart from the normal ingredients already considered, glucose or dextrose is often used for sweetening purposes in place of cane sugar ; while gelatine and sodium alginate are employed as stabilisers, these substances imparting consistency and preventing crystallisation of the mix. The materials or ingredients which necessitate storage should be kept in suitable covered containers. These should be housed in a suitable storeroom and should be issued as required. The storeroom should be maintained at all times in a clean and sanitary condition.

The operations of *mixing* and pasteurisation are usually carried out in the same vessel. The mixing process should take place quickly to ensure a good-quality product. The mix must be properly balanced ; if this point is neglected a poor-quality article will result. Ingredients should be accurately measured or weighed, the liquid materials being placed first in the mixing vat, to be followed by the solid substances. During subsequent heating the milk powder, sugar and gelatine are added in that order. If sugar is added after processing, the mix will be less viscous, a better whipping product, which will not melt at room temperatures so readily, being obtained. If the mix has to be kept for one hour or more before being heat treated, it must be maintained at a temperature below 45° F. This is a legal requirement. In this connection it should be remembered that the mix of a good-quality ice-cream can sour as readily as milk. The utensils, stirrers, etc., should be maintained in a cleanly condition. Following cleansing and sterilisation, they should be stored in a satisfactory manner.

Since the end of the War the quantity of ice-cream produced from a *cold mix* has considerably increased. This increase is presumably due to the ease with which a cold mix can be prepared and to the expanding use of counter freezers. Any cold mix powder used must have been evaporated from a liquid mixture which has already received heat treatment as required by the Ice Cream (Heat Treatment) Regulations, 1947. The mix must have been subjected to a temperature of not less than 150° F. for thirty minutes, or 160° F. for ten minutes, followed by cooling to 45° F. or below. As the only liquid milk available must be surplus to normal consumer requirements, and as such milk will almost certainly have a high bacterial content, the bacterial content of ice-cream manufactured in this way is likely to be excessive unless pasteurisation is efficient. Although cold mix powders must have been heat treated prior to sale, there is no guarantee that re-contamination has not taken place prior to manufacture into ice-cream, e.g. during packing. The ingredients are thoroughly mixed, the whole being frozen and sold almost immediately. When reconstituted with water, cold mix powders must be converted into ice-cream within one hour of such reconstitution. If any delay occurs between mixing and freezing, the bacterial content is likely to be further increased. In spite of the above requirement, there is no guarantee that immediate freezing is practised. The number of inspectors required to ensure that this procedure was being invariably followed would be very large. Many ice-creams prepared from cold mix powders are low in food value. A chemical standard is thus an urgent necessity.

Pasteurisation of the mix is extremely important and should receive the greatest care and attention. Pasteurisation dissolves those materials which require the application of heat, prepares the mix for homogenisation and destroys the vast majority of pathogenic bacteria present. Pasteurisation also destroys the viscosity. This is subsequently restored by homogenisation. Efficient pasteurisation is more difficult in the case of an ice-cream mix than with milk. The mix is thicker and more viscous, even heating throughout the batch presents a definite problem, while there is more chance that some of the material will escape adequate heating. In addition, the transference of heat is slow and not so uniform as is the case with milk. " Hot spots " and overheating may occur, with the production of burnt flavours in the final product. The outstanding risk to public health lies in the underheating which may occur. Indeed, if pasteurisation is not properly carried out, it merely represents a waste of time and money. The mix is usually processed in batch holders of various sizes, of the type and in the manner already described for milk (see p. 158). Temperatures of 150° F. for thirty minutes or 160° F. for ten minutes are legally required. Horizontal coil pasteurisers are also used for processing. Agitation must be provided with all types. This ensures that no part of the solid matter in the mix remains undissolved and guarantees that each portion receives its proper quota. The agitator should be capable of speedy removal for cleansing purposes. Vacuum processing is employed abroad for mix treatment, the substance being treated under vacuum at temperatures ranging from 200° F. to 230° F. or higher. Efficient means of temperature control should always be provided.

Homogenisation of the mix after it leaves the pasteuriser is applied by all large manufacturers. This process takes place at a pressure of between 2,500 and 3,500 lb. per square inch, the pressure varying according to the composition of the mix. If the pressure is too low the fat will not be completely emulsified. The whipping of the article will also be affected, as will the body of the resultant product. Excessive pressure results in too great a viscosity. Increased whipping time in the freezer is then required to obtain the desired overrun. While increased pressures produce a smoother-textured and more resistant product, a dry, waxy consistency will result. The fat globules are broken up during homogenisation and distributed evenly throughout the mass, forming a permanent fat emulsion. The ingredients are effectively and intimately mixed, the finished article being ensured of a smooth texture. The ageing period of the mix is reduced by homogenisation, while its whipping qualities are improved and a higher overrun in the freezer obtained. The viscosity of the mix is increased by the addition of more non-fatty solids such as sugar. If the mix is pasteurised and homogenised at low temperatures with high pressures and the ageing period is lengthened, viscosity will be increased. Excessive agitation in the ageing vat induces decreased viscosity. The same result follows pasteurisation and homogenisation at high temperatures with low pressures.

Viscosity is important, exerting as it does a definite influence upon the smoothness and palatability of the finished article.

By the application of homogenisation the mix is transformed into a homogenous mass, the fat globules being reduced to approximately one-sixth of their normal size. The remaining solids are atomised and held in suspension, thus preventing further separation. The breaking up and complete homogenisation of the mix gives a greatly improved product of thoroughly even consistency, smoother in body and richer in flavour. It also minimises any danger of the fat content of the mix being churned during freezing operations. Two-stage homogenisation is sometimes used to prevent clump formation of the fat and to procure a better-whipping mix. This procedure is not general in this country although popular in the United States of America. In all homogenising apparatus the food contacts should be constructed of stainless steel. Precautions must be taken to prevent leakage by the pistons. The homogeniser should be cleansed and sterilised immediately after the day's work has been completed. Microscopic examination of the mix should be regularly carried out to check the efficiency of the process.

Cooling is essential after the mix leaves the homogeniser. The temperature should be reduced rapidly to between 34° F. and 40° F. to prevent bacterial multiplication. The Ice-cream (Heat Treatment) Regulations, 1947, state that the mix must be reduced to not more than 45° F. within one and a half hours of processing, and must be maintained within such temperature limits until frozen. Lower temperatures are, of course, to be preferred. Various types of cooler are employed, all of which require the use of some refrigerant during the final stages of treatment. Surface coolers may produce a freezing-on of the mix on their lower surfaces. This is usually due to bad management. If such freezing-on does occur the efficiency of the cooler is reduced and the desired low temperatures may not be attained. As the mix has lost the greater part of its initial bacterial content after pasteurisation, it is extremely liable to re-contamination if carelessly handled. Surface coolers should be provided with some form of protective covering if air-borne contamination is to be avoided. Tubular coolers and those of the plate heat-exchanger type are often employed. These afford complete protection of the mix from any chance of atmospheric contamination, provided the apparatus is in clean condition. Whichever type is used, cleansing is important. Particular attention must be paid to the cleansing and sterilisation of tubular apparatus.

The use of the term "*ageing*" may sound paradoxical, especially when it is remembered that ice-cream is a perishable article. This process is, however, essential because of the beneficial effect which it exerts upon the whipping of the mix, the body of the product and rapid freezing. The process is carried out in an ageing vat. This is a tank similar to that used for pasteurisation. The ageing vats should be installed in a separate room, used solely for this purpose. The mix is held for twelve to twenty-four hours at temperatures ranging from 34° F. to 40° F. Brine is circulated in the annular circular space of each tank. The internal surfaces should be constructed of stainless steel or glass-enamelled metal. *Gentle* agitation should be provided. Violent agitation will disturb the viscosity of the mix. The process increases both the acidity and viscosity of the mix. It has been reported that all the benefits derived from ageing take place within two to four hours of the product entering the ageing vat, particularly if gelatine has been employed in the mix. When sodium alginate is used, the increase in viscosity occurs as soon as the mix is cooled, so that ageing assumes lesser importance. Rennet is sometimes used to accelerate the ripening process. Less stabiliser is required when rennet is employed.

The ageing process is followed by *freezing*, required before the ice-cream can be regarded as saleable. A freezer cools the substance to as low a temperature as practicable. This hardens the product, incorporates a predetermined amount of air into the mix, provides a proper swell or overrun and mixes any flavours or fruit which may have to be added. The mix is worked to the desired consistency in the freezer, air being incorporated to provide an overrun of between 80 and 90 per cent. by volume. During the freezing process the mixture begins to increase in volume, this increase taking place at temperatures ranging from 34° F. to 29° F. The temperature remains stationary at 29° F. for some time, due to the latent heat of freezing. The desired overrun is best obtained by means of a horizontal freezer. This should freeze the mix quickly and should have dashers, designed to ensure a rapid overrun. The freezers are usually arranged so that the mix can flow by gravity from the ageing vats. They may either deal with the mix in separate batches or provide a continuous output. A batch can usually be frozen in twelve minutes, the frozen cream being withdrawn at a temperature of 24° F. to 26° F., after which it is packed and placed in a hardening room. When withdrawn from the freezer, the cream should be capable of flowing. It should, in addition, be heavy and thick and form a dull, non-glossy mass without splashing. Premature withdrawal results in poor texture, due to the large ice crystals which form during the hardening process. Rapid freezing is essential if a smooth ice-cream is to be produced.

The *continuous freezer* is now popular, but is not a profitable method of freezing unless large quantities of ice-cream have to be produced. The mix is frozen during its progress through the barrel of the apparatus, at temperatures between 21° F. and 22° F., the time taken being approximately one minute. Exact control of overrun is possible. The ice crystals present in the final product are more numerous and smaller than is the case when the mix is frozen in batches. This is important, as there is a direct relationship between the ice crystals, the cold effect upon the palate and the distinctiveness of flavour. A product containing large ice crystals imparts a cold feeling to the mouth with a consequent loss of flavour ; a poor texture also results. Minute ice crystals in the product impart a warm feeling to the mouth. This enhances the flavour, while the ice-cream has a smooth, even, close texture. When the crystals are small, hardening requires less time and packages may be filled direct from the freezer.

Overrun in ice-cream is extremely important, as the product would be unsaleable without "lightness" obtained by thorough aeration of the mixture. Care must be taken to avoid too high an overrun, otherwise the ice-cream will be frothy and will melt too quickly in the mouth. Alternatively, if the overrun is too low, a heavy, soggy product will result. This latter is more distasteful to the majority of customers than is a highly-aerated product. With modern continuous freezers it is very easy to obtain so high an overrun by the incorporation of air that many manufacturers are tempted to exceed good business limits. The overrun is usually calculated in relation to the amount of solids present in the mix. Thus an ice-cream containing 35 per cent. total solids should have an overrun of between 80 and 85 per cent. This would be a fair business proposition. Any unsold ice-cream should not be re-frozen. If this is done the bacterial content will be increased, while an inferior product will result. It is a legal requirement that unsold ice-cream should be re-processed before being again frozen.

The *hardening process* may take place either before or after packing. This procedure is important, as the fine texture of the ice-cream as it leaves the freezer may be destroyed by improper hardening. The frozen cream is stored at temperatures between 0° F. and – 30° F. for six to twenty-four hours, such temperatures being necessary to ensure quick hardening and to maintain the overrun. If the contained air in the cream is allowed to leak from the product the bulk will be considerably diminished. Hardening or refrigerated rooms are used for this purpose, the product being stored on shelves composed of piping carrying the refrigerant. "Tunnel," or continuous hardening is sometimes employed.

Packing takes place either before or after hardening. A very high overrun is neither necessary nor desirable in packaged ice-cream, as none of the added air is lost as is the case when ice-cream is served in portions. If hardening takes place after packing, the cream is run from the freezer into moulds for hardening prior to splitting and cutting into bricks. The ice-cream may also be run into 2- or 4-gallon cans, or into cups or tubs. The product should not be too hard if it is to be filled into containers of this type, otherwise filling will be difficult and the containers will be imperfectly loaded. Many varieties of ice-cream bricks are now wrapped in parchment paper, some being covered with chocolate. Because of this the hygienic quality of the wrapping paper is important. Only the highest-quality paper should be utilised for this purpose.

Storage and distribution are important. Improperly stored ice-cream tends to separate into its original constituents. The watery element freezes into sharp ice particles, the product appearing gritty to the palate. Constant storage temperatures are therefore essential. In the refrigerated shop cabinet lengthy storage causes shrinkage, due to the escape of air incorporated as overrun. Transport in cans has now been largely superseded by non-returnable cardboard packages, whose inside surfaces should be finished with white wax. When sealed, such packages are strong, airtight and hygienic. Little time is required to assemble these packages, while the cleansing of returned cans is avoided. Solid carbon dioxide is widely used as a refrigerant during transport and sale. This substance is light, produces no liquid on melting, is easy to handle and has been used for "take home" packages with considerable success. One gallon of ice-cream can be maintained in good condition for twenty-four hours with 2 lb. of carbon dioxide. Attempts have been made to produce eutectic "inserts" from ice and salt. Those so far employed are heavy, difficult to handle and produce liquid on melting. For these reasons they cannot be recommended. Conservators of various types are used for counter storage and sale, employing a variety of refrigerants. They operate economically and can be used for prolonged periods with little or no attention beyond periodical servicing.

As the result of the use of a cold mix, *counter freezers* have become very popular. Freezing takes place in one compartment, the product being then removed to an adjoining compartment for storage and service. The packaging of ice-cream in cups and bricks is rapidly replacing distribution in bulk. From the hygienic point of view this is a step in the right direction. Factory-packed ice-cream can be produced under much more sanitary conditions than is the case in the majority of retail shops. Direct distribution of the product by means of tricycles and vans has largely influenced the development of the small package. It is important to note that the Ice-cream (Heat Treatment) Regulations, 1947, require that, once frozen, no ice-cream shall be sold or offered for sale unless it has been continuously stored at a temperature not exceeding 28° F. Should the temperature rise above this level the product must be re-processed, cooled and stored within the temperature limited set out in the regulations. For bulk ice-cream, the ideal serving temperature appears to be 10° F. If served too cold, the substance will deaden the palate, have little flavour and will be difficult to serve. If served at too high a temperature, it will melt rapidly and will be inclined to have a sweet and even a sickly taste.

Premises and Plant

Premises used for the manufacture of ice-cream should be hygienic in every respect and should be maintained in a satisfactory condition. Lack of sufficient light is a common fault with such premises. This defect not only affects the health of the employees but tends to prevent the maintenance of the premises in a scrupulously clean condition, since dirt cannot be easily detected. Lack of suitable ventilation also reacts upon the health of the employees, preventing the escape of steam and other odours from the processing rooms. The raw materials should be protected from contamination. Suitable accommodation for the storage of such substances and also for the storage of waste matters must therefore be provided. Many premises lack an adequate pure water supply. This hinders thorough cleansing of the plant, the utensils and frequent washing of the employees' hands. It is often found that premises have not been properly planned, many old buildings, sketchily adapted for processing, being still in use. The siting of the apparatus concerned should ensure easy cleansing. There should be no overcrowding of plant. Corners and dark spots where dirt may accumulate should be avoided.

Walls and ceilings should be constructed of smooth, hard and non-absorbent materials, and should be free from crevices and angle joints. Glazed bricks or tiles are admirably suited to this purpose. Floors of tiles or concrete are essential. Wooden floors should not be countenanced. The crevices between the boards of such floors allow dirt to accumulate, while the wooden surfaces are easily indented, so that cleansing is hindered. Constant cleansing renders the wood soft, when the flooring will absorb a considerable quantity of moisture and filth. All angles between walls and floors should be rounded. Floors should be laid with a sufficient fall for drainage purposes. Tiled floors are especially desirable, since they readily reveal any lack of cleanliness. Whatever type of floor is provided, a non-slip finish is essential. Drainage should be adequate. Ventilation should be sufficient to remove all steam and other vapours from the premises, damp air encouraging the growth of moulds and fungi. The various rooms in use should be suitably provided with natural and artificial lighting. Rubbish should be frequently moved to the outside of the premises, the containers being disinfected after use. The interior fittings of the building are important. Shelves should be fitted on stands away from the walls or fixed by means of iron brackets, metal racks being preferable to wooden shelves. Where tables are required, these should be provided with impervious metal tops. Wooden-topped tables should not be employed, as this material readily absorbs moisture and can never be rendered sterile. When plant is inspected, a careful note should be made of the conditions existing in the various rooms, together with the methods employed in cleansing and sterilisation. Rinse or swab samples from all surfaces should be obtained at frequent intervals for bacteriological examination.

While it is a fact that the complete *plant* required for the small vendor comprises a container fitted with a stirring gear and suspended in a tub of ice and salt, it is also a fact that a dozen or more complicated pieces of apparatus may be required for each of the separate stages of large-scale manufacture. The design, manufacture and installation of modern plants occupy the constant attention of engineering specialists. Designs and methods of manufacture are constantly changing. As the result of improvements made it is now possible to obtain a purer and smoother-textured product by more economical means. The size of the plant required is governed by the quantity of ice-cream to be manufactured. Processes should be arranged in sequence, since quick handling of the frozen unhardened cream is essential. Pasteurising, homogenisation and cooling are usually carried out on one level, with ageing at a higher level, so that gravity discharge to the freezers is possible. Hardening rooms may be situated at ground level, but may be arranged at a lower level to facilitate gravity discharge from the freezers. All plant should be constructed with a view to easy cleansing and sterilisation. Plant should be readily dismantled and assembled and must be sufficiently strong to withstand constant usage. It should provide a product of uniform quality and be simple and reliable in operation. Care should be taken to ensure that the product is not contaminated by any of the apparatus employed. Glands and stuffing boxes should be viewed with particular suspicion. Pumping should be reduced to the workable minimum ; equipment should be constructed of materials which will not be affected by chemical action. Stainless steel or glass-enamelled metals are particularly suitable, although chrome nickel or monel metal can also be employed. The materials should not be subject to corrosion. Copper, steel or gunmetal surfaces should be heavily tinned, otherwise unpleasant odours or flavours may be produced in the cream. Stainless steel is probably the best material, since it is easily cleansed and has a long working life. Pipe-lines should be constructed in short sections so that they may be easily dismantled for cleansing and sterilisation. The scraper blades of the freezer should be properly maintained. If they are allowed to become dull the efficiency of the apparatus will be decreased and the body and texture of the product impaired. The quick transference of heat will also be affected, due to insulation through ice forming on the internal surfaces of the freezer. The length of time required for freezing depends upon the degree of dullness of the blades.

However satisfactory plant may be, its *operation* must be properly carried out if satisfactory results and a uniform product are to be maintained. The essentials are suitable appliances, the maintenance of essential temperatures, speed of mixing, scientific control, with efficient cleansing and sterilisation.

Cleansing of Plant

Any plant used for food manufacture must be efficiently cleansed and sterilised, ice-cream plant being no exception to this rule. Emphasis must be placed upon the word " efficient." The objects of cleanliness are to ensure quality and safety in the product. However much quality may be desired, the safety of the article remains of paramount importance. The methods employed by the average "back-yard" producer can seldom be termed satisfactory. It is difficult to sterilise properly without steam; these vendors cannot usually afford facilities for its generation. Really hot water is suitable, but, again, small vendors do not always possess the means of providing copious supplies of hot water or of maintaining the water at the requisite temperature. It would not be entirely wise to suggest that this type of producer should use chlorine solutions as sterilising agents, since it is vitally important that preliminary cleansing should be efficient if the employment of such sterilising agents is to be satisfactory. The normal method of cleansing practised by the small vendor usually consists of rinsing the various receptacles in cold water, followed by a perfunctory washing in lukewarm water. The utensils are then wiped with a cloth, which is often in a soiled condition.

An article may be said to be sterile when it harbours no living bacteria or spores. After proper cleansing, sterilisation is therefore essential. Boiling water, steam or hypochlorite solutions may be used for this purpose. Unless the utensils can be totally immersed in boiling water, this method is not to be recommended as, when the water is removed from the boiler, the temperature drops and efficiency is decreased. This may be dangerous and is often the cause of inefficiency. Chlorine can be successfully employed if proper care is taken, but adequate dilutions are essential. Particular care should be taken to ensure that the utensils are really clean before these solutions are applied. There is no real substitute for steam if sterilisation is to be efficient. In this instance, efficiency is a matter of time and temperature. The temperature should always be maintained for ten to twenty minutes at 210° F. Following treatment, any drops of condensate will be quickly dried off by the heat of the metal. If moisture does remain, no attempt should be made to wipe it off. Generally speaking, steam is to be preferred when all surfaces can be brought up to sterilising temperature. When used for sterilisation, hot-water temperatures should never fall below 180° F. The strength of any chlorine solutions should be frequently checked.

Cleansing and sterilisation should always be methodical. Cold or tepid water should be pumped through all sections of the plant as soon as processing is completed. This should be followed by hot water and detergent. The plant should then be dismantled and all portions well scrubbed. Clean hot water should be pumped through and all containers filled to remove all traces of detergent. Pipe-lines and small parts should next be steam sterilised in a suitable chest. Homogenisers demand particular care in cleansing and sterilisation. When re-assembled, the plant should receive a final treatment, water at not less than 180° F. being pumped through. Steam or a chlorine solution may also be used. When cleansing and re-assembly have been completed, the plant is often allowed to remain unsterilised until immediately prior to the next day's processing, when warm chlorine solution is pumped through to sterilise plant surfaces and warm up the apparatus.

Freezers present greater difficulty. When operations have been completed, any cream remaining in the apparatus should be drained away and all the internal surfaces washed thoroughly with cold water. The freezer should then be half filled with cold water and operated for at least one minute, after which the water should be drained off. The freezer is next washed with hot water and detergent at 180° F., the dashers and beaters being removed for separate cleansing. Final sterilisation is carried out in the usual manner. When all the plant has been cleansed and sterilised, the floors and walls should be well scrubbed. Tables and shelves should be similarly treated. In short, absolute and unvarying cleanliness is essential.

Manufacturing Problems

The manufacturer of ice-cream has many difficult problems to face, particularly during winter, when reduced demand implies fewer mixes, fewer freezings and longer storage periods, not only for ingredients but also for the finished product. Prolonged storage favours the development of flavour defects. These are the result of physical and chemical changes either in the mix or in the manufactured article. Taints emanating from metal surfaces with which ingredients such as milk have come into contact may arise and present a special problem. Copper surfaces are particularly liable to this defect. If copper receptacles must be used, their surfaces should be maintained in a bright condition, free from metallic oxides, as copper corrodes rapidly when not in frequent use. During winter months ice-cream is stored for longer periods in the hardening room and in dealers' cabinets. If a tallowy flavour is originally present, prolonged low-temperature storage will emphasise this defect. Cream and unsalted butter are cold-stored for varying periods during the winter months. The fats contained may undergo chemical changes, particularly in the presence of certain metals, if the storage temperatures are too high or if the articles are exposed to the atmosphere. This may cause the fat to develop a tallowy flavour shortly after the ice-cream has been frozen. Poor-quality fats very often produce a stale tallowy flavour. Copper salts are usually responsible for this defect.

When ice-cream is consumed, it occasionally produces a rough powdery sensation upon the tongue. It is then termed "sandy." This defect is due to the presence of lactose crystals. At hardening room temperatures the solubility of milk sugar in water is low, so that, when a certain concentration of lactose in the mix is exceeded because of a high serum or total solids content, the lactose may crystallise and produce "sandiness." Fluctuating temperatures in the hardening room or in dealers' cabinets will hasten the formation of lactose crystals. In order to avoid this defect, the lactose content of the mix should not exceed 8·5 per cent. of the water content. A lack of salt balance in milk used in the mix may result in slow whipping in the freezer. Winter mixes whip more slowly than do summer mixes of identical composition. Calcium citrate or phosphate salts are often employed to remedy this lack of salt balance, the substance selected depending upon which salt is lacking. Butter or frozen cream used in winter also produces slow whipping. With frozen cream the addition of sugar before freezing will accelerate the whipping process. This tends to prevent the churning of fat in the freezer, while the thawing of the cream allows the fat to remain as a normal emulsion.

Water Ices

Flavoured water ices of various types enjoyed a limited sale prior to the War. Since hostilities ended there has been a rapid increase in the number of water ices manufactured and sold, due to the scarcity of suitable materials for normal ice-cream manufacture and the cost of post-war ice-cream. These ices, which are sold under a variety of names, consist of a shaped block of flavoured ice, the ingredients being water and some variety of flavouring material. Exorbitant prices are charged for water ices having regard to their very limited food value. Being cold and sweetly flavoured, water ices are in great demand by children. The result has been that many small back-yard vendors have turned their attention to this very profitable form of merchandise. As the ingredients required are unrationed, there is no difficulty in obtaining supplies. The production of water ices is often unsupervised, the conditions under which they are manufactured varying considerably. The trade has increased to such an extent that local authority officials are paying increasing attention to it, although their powers of supervision are somewhat limited. Many authorities have adopted a code of practice relating to the production of water ices on the lines set out in Appendix 2.

Composition

It is extremely difficult to determine a standard of composition for ice-cream, owing to the variation in the kind and quantity of materials used in its manufacture. If circumstances permitted, ice-cream should be a dairy product, being manufactured from milk, cream and sugar, with or without the addition of eggs. The finished product should contain not less than 8 per cent. of milk fat and not less than 10 per cent. of milk solids-not-fat, i.e. a total of 18 per cent. of total milk solids. By far the greater proportion of ice-cream now sold in this country is an inferior article, containing not more than 5 per cent. butter-fat and no eggs, either liquid or dried. It has been suggested that products such as these should be known as "ices," the term "ice-cream" being a misnomer. In America, where ice-cream is an almost universal item of diet, the product must be made from cream and sugar and must contain not less than 12 per cent. milk fat. An American frozen ice-cream mix is considered to be adulterated if it contains more than 0·5 per cent. of stabiliser or less than 1·6 lb. milk solids per gallon. A bacterial standard is also fixed.

A standard of food value has now been formulated in this country by the Ministry of Food, in spite of the limited materials available at the present time. This is particularly desirable when one remembers the large and increasing quantities of ice-cream consumed annually and when the chemical analyses of many modern ice-creams are taken into consideration. The present legal definition of ice-cream includes water ices. This is a palpable mistake which is in immediate need of amendment. The Food Standards (Ice-cream) Order, 1950, which came into operation on March 1st, 1951, lays down minimum standards for the composition of ice-cream. *Ordinary ice-cream* must contain at least 5 per cent. fat, 10 per cent. sugar and 7½ per cent. milk solids other than fat. *Ice-cream containing fruit* may have a lower non-fatty milk solids content, but the total content of fat, sugar and milk solids not fat must be at least 25 per cent. with minimum contents of 7½ per cent. fat, 10 per cent. sugar and 2 per cent. milk solids not fat.

A particularly serious omission is the lack of bacteriological standard. It must be admitted that the methylene-blue test has been introduced as a means of gauging the bacterial content of the finished article. This method of examination has many disadvantages and is much too lenient for ice-cream produced under what should be hygienic conditions.

Nutritive Value

Ice-cream, once looked upon as a seasonal dish, is now universally in season. When constituted of suitable high-grade materials it will possess real food value. Ice-cream has been described as a safe, wholesome, nourishing food which can be easily utilised by the body to produce energy, besides providing a valuable source of vitamins A, B_1, E and G. This might well be true if all ice-cream were pure. Unfortunately, the many outbreaks of disease which have followed the consumption of ice-cream lead one to believe that all its varieties do not conform to these standards. In addition, much of the product now sold is composed of poor low-grade materials and has an extremely low food value.

If ice-cream contains cream in addition to milk and sugar it is a most valuable protective food and represents one of the most attractive ways in which dairy products can be served. Besides being extremely palatable, good ice-cream contains all the vitamins and calorific value of whole milk and cream together with the added serum solids and sucrose. Its mineral content is lower than that of milk, but it is far in advance of butter as a source of calcium and phosphorus. An average portion of good-quality ice-cream contains twice the vitamin A content of milk, and four times that of butter, while it is a valuable source of vitamins B_1, E and G. It is not, however, a good source of vitamins C and D. Ice-cream also possesses a high energy value, while its proteins are more completely assimilated than those of most other foods. Gelatine, which is often used in the mix, is a valuable nitrogenous food and adds to the digestibility of the product by limiting the size of the milk protein curds formed in the stomach. Ice-cream also has the advantage of being added to the dietary as a special privilege rather than as a basic food. As regards tissue building and the generation of energy, ice-cream is much more useful than a large variety of articles popularly supposed to be foods of high value.

Ice-cream is particularly useful in the dietary of the sick and under-nourished, such individuals being usually willing to consume ice-cream while refusing other foods of comparable nutritional value. Its high palatability stimulates the secretion of saliva and gastric juices. It is easily digested, its fat content being finely dispersed by homogenisation. A normal portion of good-quality ice-cream contains twice as many calories as a glass of milk, and four times as many as the quantity of potatoes usually consumed with the main meal. One pint of good-quality ice-cream is equivalent to the energy value of seven eggs, 5 lb. of tomatoes, more than $1\frac{3}{4}$ lb. of chicken or $\frac{2}{3}$ lb. of steak. Ice-cream may also be used during convalescence as a vehicle for conveying to patients many articles of food or medicaments which would normally be refused. Thus drugs, cod-liver oil and the like may be mixed with ice-cream, its low temperature and taste disguising the original flavour.

The excessive consumption of ice-cream should be avoided. In the United States of America this practice is said to be at least partly responsible for an increased dyspepsia rate through constant chilling of the membrane of the digestive tract. It will be readily appreciated that the excessive consumption of ice-cream primarily for pleasure, or in order to reduce an overheated body temperature, is likely to do more harm than good. The sudden introduction of a large quantity of cold material into the stomach is seldom beneficial, and may be harmful. Ice-cream should therefore be eaten sufficiently slowly and in reasonable bulk to permit of an equalisation of temperature by gastric circulation. Unless the product is eaten with inordinate rapidity, the body is able to effect this equalisation. As a rule, adults consume ice-cream slowly, children showing much greater speed in consumption.

Bacterial Content

When ice-cream contains milk or any product of milk the bacterial content closely resembles that of the dairy products incorporated into it. As, however, these materials are not generally available at the present time, it can be assumed that the high bacterial content so often found in ice-creams is due to (*a*) dirty utensils, (*b*) ingredients and (*c*) careless handling of the substance during and after manufacture. Ice-creams produced from cold mixes are often the worst offenders. The efficient pasteurisation of milk or cream used in the composition of ice-cream will result in a considerably reduced bacterial content, although re-contamination often nullifies the benefits obtained. In dairy type ice-cream putrefactive organisms develop more rapidly at low temperatures than do lactic-acid types. Freezing of the mix and its subsequent storage at low temperature does not destroy the organisms present, merely inhibiting their growth. Pathogenic organisms have remained alive in ice-cream for lengthy periods, even when the product has been stored at temperatures well below freezing point.

Pathogenic bacteria of animal origin, such as *M. tuberculosis* and *Br. abortus*, have not apparently caused any consumer infection, although the possibility of such an occurrence should not be lightly dismissed. There can be little doubt that the majority of pathogenic organisms found in ice-cream are of human origin. They obtain entrance to the product during production and sale. The causative organisms of typhoid and paratyphoid fevers, dysentery, scarlet fever and other human diseases have been the cause of many disease outbreaks, while several epidemics of food poisoning due to infection of ice-cream with *Salm. aertrycke*, other salmonella organisms and by *Staphylococcus aureus* have been reported. The number of *non-pathogenic bacteria* found in ice-cream are only limited by the bacterial quality of the materials used in manufacture. Milk which has a high bacterial content will produce an even higher count in the finished article if the mix is not sufficiently heat treated or not treated at all. The remaining constituents, such as dried eggs, sugar, cereal fillers and gelatine, all add their quota, as do unsterile utensils and improper handling. In addition to high bacterial counts, colouring materials may also contain large numbers of yeasts and moulds. Raw materials and utensils must indeed be regarded as most prolific sources of bacterial contamination, although many additional organisms may be added from the atmosphere, from various processing appliances, such as pasteurisers, homogenisers, cooling and ageing apparatus, and from packaging, brick-making and wrapping machines. The air whipped into the mix does not appear to add appreciably to the bacterial content. Unhygienic methods of handling or serving by vendors may result in serious contamination, while infected personnel or " carriers " can add both pathogenic and non-pathogenic types in large numbers. Many vendors seem to think that they are adequately protected by the low temperatures at which the material is stored, although this affords no security whatsoever. Home contamination is not unimportant. Such contamination can occur in many ways, the avoidance of which is purely a matter of common sense and care.

Epidemiology

Many outbreaks of disease due to ice-cream have occurred in the past. In spite of improvements in methods of production and distribution, it is feasible that many more will occur in the future. On the other hand, the number of outbreaks reported are few in relation to the quantity of ice-cream consumed, although this should not be taken to mean that there is no need to strive constantly for still further improvement. Indeed, no permissible standard short of the optimum should be permitted. The characteristics of an epidemic due to infected ice-cream follow closely upon those already outlined in relation to milk (see p. 151). The investigations required are also similar.

Typhoid fever is one of the principal infectious diseases transmitted by ice-cream, the sources being individuals suffering from the disease, "carriers," contacts, fæces and urine. Infected persons and "carriers" are the principal sources of typhoid bacilli, the ice-cream being contaminated by the uncleanly habits of the persons handling it. Fly infection is also possible, whilst a polluted water supply may be a contributory factor. The medical examination of all persons handling ice-cream, including the appropriate blood tests, should be carried out where necessary. In 1916, 200 cases of typhoid infection due to infected ice-cream were notified in South Shields; a similar outbreak involving 120 persons was reported from Luton in 1924. Many other outbreaks have been notified, one of the latest being at Aberystwyth in 1946, when 124 cases occurred, with three deaths. *Paratyphoid fever* outbreaks have also resulted from the consumption of ice-cream, thirty cases being notified from Wisbech in 1923, sixty-three cases from Norwich in 1926 and from Perth in 1945. An outbreak of *dysentery* due to ice-cream and affecting twenty-four persons, with one death, was reported from Worcester in 1930. *Septic throat* outbreaks have been reported from the Continent and from America; an outbreak of *scarlet fever* was reported in Flint, Michigan, in 1924, 116 cases being notified. In 1937, an outbreak of *diphtheria* affecting thirteen persons was reported from Glasgow. There were six deaths. Many outbreaks of *food poisoning* have been traced to ice-cream. Forty-nine persons contracted food poisoning at Stevington in 1921, several hundred cases were reported from Chepping Wycombe in 1923, while 300 persons were affected in Bath (1927), with one death. All three outbreaks were definitely traced to ice-cream. The incidence of disease outbreaks due to ice-cream during recent years has declined. This is possibly indicative of improved methods of production and distribution. In spite of such improvement, danger still exists and may at any time become intensified if control is eased.

Control

Control of the production and distribution of ice-cream is vested in local authorities, who are responsible for administration of the appropriate legislation. While the larger local authorities carry out their duties adequately, the production of ice-cream in many areas, particularly rural districts, does not always receive the supervision required. *Registration* of premises is compulsory. Such registrations should be renewable at annual intervals. Hotels, restaurants and similar types of premises are at present exempt from registration. This point calls for immediate rectification, as many kitchens and rear premises in such establishments, any of which may be used for the preparation of ice-cream, cannot be said to be suitable, particularly in view of the fact that vegetable cleansing and dish washing take place in the same too. Although exempt from registration, any ice-cream produced therein must comply with the provisions of the Ice-cream (Heat treatment) Regulations, 1947.

Inspection of premises and plant is important and should be carried out at frequent intervals, particular attention being paid to the protection of ingredients from contamination and to the temperatures employed in processing. The *personnel* employed also call for serious consideration. It would be an advantage if responsible individuals employed in the ice-cream trade as well as premises were registered. Power to refuse such registrations and to remove unsatisfactory persons from the register should be available. The cleanliness of overalls and caps, together with the facilities available for hand washing, and their proper use, should be noted. Employees should be prohibited from spitting and smoking during working hours, particularly in the processing rooms ; the notification of all infectious and skin diseases should be compulsory. The health of the personnel should be inquired into, comprehensive medical examinations at frequent intervals being desirable. *Materials* used in the composition of ice-cream should be inspected. A standard specifying the ingredients which may be used represents an urgent necessity. The conditions under which ingredients are stored should be noted. Dairy products, when used for manufacture, should always be stored at low temperatures until required for use. Any milk or cream should be subjected to suitable bacteriological tests.

The final product should also be subjected to *bacteriological examination* at frequent intervals, bacterial counts, coliform estimations and methylene-blue tests being carried out. The *methylene-blue test* is now recommended as a standard test but has no legal significance. By means of this test, ice-cream may be placed in one of four grades according to its bacterial quality. Other countries have bacterial standards for ice-cream ; some such standard is an urgent necessity in this country. High bacterial counts may be due to poor-quality materials, unsatisfactory processing or carelessness on the part of employees. If high bacterial counts in the finished product are reported, samples should be taken at different points in the plant to discover the exact source of contamination.

Chemical examinations are important and provide evidence as to the quality of the finished article, possible adulteration and correct processing, the phosphatase test being applied for the latter purpose. Ice-cream produced or stored in unsuitable metal containers may contain traces of poisonous metals, particularly zinc. If milk is used as an ingredient, this substance may gain entrance from the milk churns. Galvanised freezers represent another source of zinc infiltration. Legal chemical standards have now been fixed in this country. Higher chemical standards are in use abroad and should be available here as soon as the shortage of ingredients allows. It would probably be unfair to fix a high chemical standard for ice-cream at the present juncture owing to existing shortages. When conditions return to normal, however, this gap should immediately be filled. In fixing any final chemical standard it should be remembered that the solids-not-fat content possess a high nutritional value and that excessive butter-fat, besides being expensive and increasing the price of the product, affects its digestibility. A product which has a reasonable fat content is most palatable and refreshing.

The *distribution* of ice-cream raises many problems. If a suitable article, produced under hygienic conditions, is available to the distributor, he should take every care that pollution does not occur *en route* to the consumer. Vehicles, premises and personnel should be regularly inspected and supervised, with particular emphasis on cleanliness. Suitable metal containers which will not taint the product should be used. Ice-cream should preferably be retailed only in closed cartons or wrapped blocks. The condition of the *servers* used for the sale of loose ice-cream is not always as satisfactory as could be desired. Particular attention should be directed to the condition of the liquid in which such servers are stored between use. This liquid is often highly polluted and has yielded very high bacterial counts. Other serving equipment may also be grossly contaminated. Bulk ice-cream may be contaminated in the cans by the fingers of the vendor. The tops of bulk cans are often removed and not replaced, exposing the product to atmospheric contamination. The use of water containing hypochlorite solution is to be recommended for the storage of servers. Glasses used for the service of ice-cream in portions—possible vehicles of infection which are often overlooked—should be treated in the same way. Suitable detergent-disinfectant solutions should also be available for treating servers, glasses, etc.

The conditions under which ice-cream is produced and sold have caused grave concern to many local authorities and their officials. Following discussions with trade associations, codes of practice have been drafted for use by ice-cream producers and vendors, an example being set out in Appendix 2. While the more reputable members of trade associations are likely to follow the recommendations to the letter, many small vendors will almost certainly ignore all suggestions. Such vendors require constant supervision.

CHAPTER XIV

BUTTER AND MARGARINE

Butter

BUTTER represents one of our staple fatty foods. Although the quantity now available has fallen considerably, there can be little doubt that when conditions return to normal the consumption of this foodstuff will rise. Very little farm-house or fresh butter is now produced in our rural areas, its manufacture in this country being almost entirely centralised in creameries and butter factories. Large quantities are also imported from abroad. Because of this centralisation, a more uniform product is at present available. The substantial increase in imported supplies prior to the War raised the consumption of butter to a high level, the price in those days being comparable to that of good-quality margarine. In 1939 the annual consumption of butter in Great Britain was approximately 15½ lb. per head, an amount which was still far below that of many other countries. For some time before hostilities commenced butter-making at farms had almost ceased doubtless due to the guaranteed prices paid for liquid milk. It will thus be seen that, even prior to 1939, butter-making had become almost entirely an industrial process. An unsatisfied demand has always existed for farm-house butter, but so long as milk prices retain their present level it is most unlikely that farmers will revert to butter-making. In the past, the quality of farm-house butter has not been entirely reliable, being too varied in flavour and appearance to make a general appeal to popular taste.

Manufacture

Both ripe-cream and sweet-cream butters are produced for public sale. Ripe-cream butter is made from cream which has been allowed to ripen naturally by encouraging multiplication of the lactic-acid organisms originally present in the cream. Ripening may also be induced by the addition of an artificial ripening culture or "starter." This type of butter is generally regarded as being of a better quality than sweet-cream butter. Sweet-cream butter, which is manufactured from fresh cream churned at low temperatures without any form of ripening, has little flavour. Taints may develop due to the absence of "starter" organisms. Such organisms limit the growth of those bacteria which produce undesirable flavours. A substantial loss of fat in the buttermilk results when this type of butter is produced.

Methods of manufacture are practically the same in each instance. *Cream separation* is normally carried out by means of mechanical separators. (For further details see Chapter XV.) To ensure optimum aroma during ripening, cream should not have too high a fat content, 23 to 24 per cent. being normally sufficient. This permits the bacteria responsible for aroma to find nourishment in the milk sugar and citric acid, substances from which the flavouring principles originate and which impart the desired flavour and aroma. Experience has shown that there is an optimum acidity at which cream should be churned to make good butter. Excessive acidity is often reduced by neutralisation, the acidity of the cream being suitably adjusted. Although this practice is objected to in some quarters, it is not fraudulent, being an established trade practice. As milk of varying acidities is received at the creamery, neutralisation enables butter of good keeping quality and standard uniformity to be produced.

From the public health point of view, *pasteurisation* of the cream after separation is essential whatever type of butter is being produced. Milk received from a number of farms cannot be guaranteed free from pathogenic organisms however low its total bacterial content may be. If such organisms are present prior to separation, they will certainly be present in the final product unless the cream is pasteurised. Pasteurisation is also a commercial necessity, as the use of artificial ripening cultures with pasteurised cream allows the process to be scientifically controlled and ensures a more uniform product. In some cases the milk is pasteurised prior to separation. Various types of plant are used for this purpose, temperatures of 155° F. to 165° F. for fifteen to thirty minutes being used. Short-time processing is also employed, while in America, Australia and New Zealand the cream is often processed at high temperatures (200° F. and above) by vacuum pasteurisation. When this method is employed, the cream travels swiftly at 3 to 5 lb. per second past a given point, at pressures of 10 lb. and above, and is suddenly expanded in a heated vacuum chamber. A cream of greatly improved flavour is thereby produced. This method is said to improve the flavour and keeping qualities of the butter, while harmful enzymes are destroyed. The cream should be rapidly cooled to between 60° F. and 70°F., according to season. The hardness of butter depends to a considerable extent upon rapid cooling of the cream, followed by lengthy cooling before churning and refrigeration.

Cream-ripening is carried out after pasteurisation, the liquid being run into vats, where it is ripened for the churning operation. The degree of ripening depends upon the type of butter required, some markets demanding a mild- or medium-flavoured article, while others require a full-flavoured product. Two methods of ripening may be employed. The *natural method* is largely the prerogative of the farm-house butter-maker. Cream normally contains a greater number of bacteria than milk, due to the centrifugal action of separation, which causes bacteria to adhere to the fat globules and remain entangled therein. These organisms grow in normal fashion during the ripening of the cream, first fermenting the lactose and later digesting the protein. The fat is not attacked by their action but absorbs the by-products of bacterial growth, which in turn impart flavour to the cream. Lactic-acid bacteria impart a pleasant taste, while organisms of the coliform group form acetic and formic acids in addition to lactic acid, which produces an offensive taste and a pungent odour in the fat. The rate of growth and the determination of the type which will predominate at the end of the ripening period depends upon the storage temperature of the cream. For the first forty-eight hours the desirable lactic-acid organisms steadily increase. Their numbers decrease after this period. The cream thickens when bacterial growth is at its maximum. This process can be retarded by churning. If this is not done undesirable organisms, which will spoil the resultant butter, will develop.

Two or three days' supply of cream are normally mixed together on farms, the whole being churned on the third or fourth day. When each fresh batch of cream is added, the whole is thoroughly stirred to ensure level ripening. Ten to twelve hours should elapse after the last batch of cream has been added before churning takes place. The temperature of the cream during ripening should be maintained at between 55° F. and 60° F., according to season. The cream should be covered to ensure protection against contamination, repeated stirring being required. Ripe cream should possess a fresh acid flavour, be smooth to the palate and have an acidity of not more than 0·5 per cent. This method of ripening has certain disadvantages. The growth of lactic-acid organisms cannot be controlled, while, if the cream contains harmful bacteria, their multiplication during the ripening process may produce a poor-flavoured butter which will not keep. In creameries and butter factories, where large quantities of cream are handled daily, *artificial ripening* has replaced the natural method, special cultures being used for this purpose. The flavour of the resultant product depends upon the type of " starter " added to the cream. To produce a full-flavoured butter such additions are essential. " Starters " are cultures containing a predominant number of *Streptococcus lactis* organisms together with other types, such as *S. citrovorus* and *S. paracitrovorus*, known to form aromatic constituents in butter. Care must be taken to prevent the development of off-flavours which may be transmitted to the final product. A " starter " which has not been incubated for more than sixteen to twenty-four hours is commonly used. A high-acid forty-eight-hour culture will contain an increased amount of diacetyl but may impart a cheesey flavour to the butter. The diacetyl content varies from 0·1 parts per million in butter of low flavour to 2·0 parts per million in the full-flavoured variety.

Most creameries possess their own artificial cultures, which are propagated either in whole or skimmed milk. A quantity of separated milk is heated to 150° F. for twenty minutes, being afterwards cooled to 70° F. in summer and 75° F. in cold weather. The artificial culture is then added. The mixture is allowed to stand at room temperature for twenty-four hours so that the milk may thicken. A further batch of separated milk is treated in a similar manner. To this is added a small quantity of the thickened milk. This liquid is allowed to stand for a further twenty-four hours, when the " starter " is ready for use, a portion being added to the cream, which has been previously pasteurised and cooled. Ripening at temperatures between 60° F. and 70° F. takes place until the desired acidity is obtained. This varies according to the quality of the cream used and the type of butter required. If too high an acidity is developed, the butter will not keep well, particularly if salted. An acidity not exceeding 0·2 per cent. is recommended for this type of butter. For the unsalted variety an acidity of 0·3 to 0·45 is desirable. The " starter " is renewed daily in summer, and two or three times per week in winter. Pure culture " starters " are sold commercially either in liquid or powder form. Extended use is also being made of "starter" distillates which are free from yeasts, moulds or undesirable bacteria, their acidity and diacetyl content being standardised in the laboratory so that the degree of flavour in the final product may be adequately controlled.

The average temperature at which *churning* of the cream takes place varies between 50° F. and 65° F., lower temperatures being the rule during the summer months. The cream temperature is raised or lowered as required, the liquid being well stirred before churning begins. If the churning temperature is too high, the resultant butter will be soft, oily and grainless, considerable fat being lost with the buttermilk. Too low temperatures necessitate prolonged churning. In such cases the grain is small, while texture of the butter is spoiled by friction. The heating or cooling agent is circulated through coils in the ripening vats. Cream of thick consistency is thinned down with water, which should not exceed 10 per cent. of the bulk. Cream of the correct consistency should flow freely through a straining cloth. Any excessive addition of water will result in a tasteless butter of poor appearance. The cream is strained into the churns, which should have been rubbed internally with salt. These vessels should never be more than half filled, otherwise the churning process will be prolonged due to diminished force of impact during the operation. At first the churn is slowly rotated, being frequently ventilated to release gases and off-flavours. It should eventually revolve at more rapid speeds, depending upon the type of churn used. Quick churning produces small grains of butter ; uneven speeds result in large grains. Slow churning reduces the force of impact, agitation being decreased.

The speed at which butter is produced depends upon the type of churn employed, temperature, ripening and viscosity of the cream and its richness. Cream which possesses large fat globules churns rapidly, as does highly acid cream. Excessive acidity results in coagulation of the casein, which may become incorporated in the butter, from which it is difficult to eliminate. The action of churning produces violent agitation of the fat globules present in the cream. These gradually coalesce and form granules, the butter appearing in varying periods according to circumstances. Churning is terminated when the granules begin to float in the buttermilk, which should now be a bluish watery liquid. Clean cold water at low temperature is added to the churns to assist in final separation of the butter-fat. Churning should never be carried to the point where the butter is present in lumps. Casein will then be incorporated in the mass, the keeping quality of the final product being seriously impaired.

Various types of churn are employed, constructed either of wood or of metal. The wooden type is most generally employed, although during the past few years metal churns have appeared in greater numbers. The *farmhouse churn* is usually an oak barrel balanced diagonally and revolving upon two lugs which rest on a pitchpine frame. Hand operation is general, the maximum butter capacity being approximately 56 lb. at one time. Separate working apparatus is required with this type of churn. *Wooden factory churns*, which are much larger, are generally constructed either of teak or redwood. They may contain a number of wooden rollers which revolve upon horizontal axes. Up to six rollers may be provided in a churn of this type. Multiple-roll churns depend upon correct mechanical alignment to produce uniform results. Any wear or incorrect adjustment will produce lack of uniformity in the moisture content or in the distribution of salt throughout the finished article. Butter must be delivered to the rollers in a regular manner, otherwise its grain may be affected. A *single-roll churn* is becoming popular and has proved dependable. Churning is a matter of agitation and concussion. In the working process gentle, constant and uniform pressure is required. This must be applied in such a way as to avoid destroying the fine natural grain of the butter. When a single-roll churn is used, all the butter is worked in the centre of the drum, a centre roller and two shelves being provided in the churn. The butter is worked twice at each revolution of the apparatus. A *roll-less churn* has also been devised. This is easy to clean and operate and produces a first-class article. Working is accomplished by the butter dropping violently from one corner to the other.

Two difficulties in churning cream into butter may occur at all periods of the year, but are more common during the winter months. "*Sleepy*" *cream*, in which the liquid becomes sticky and adheres to the sides of the churn, is occasionally encountered. If this trouble is experienced, a small quantity of water can be added to the cream. "*Frothy*" *cream* is due to thinness, improper ripening and to faulty churning temperatures. If natural ripening is practised, recourse to the use of artificial cultures may be necessary. Warming the cream will increase its thickness, the temperature being raised or lowered by the addition of hot or cold water.

The entire process of butter-making may occupy any period from forty to sixty hours, although attempts have been made to accelerate production. In the *Escher-Wyss process* cream separated from milk enters stainless steel containers in combination with carbonic acid gas under pressure. Still under pressure, the liquid passes to a churn provided with special stirring and battering machinery, the cream being converted into butter within one minute. The grains are washed twice and are then pressed together and packed. Ripe or sweet cream may be used. It is claimed that the yield of butter is 3 per cent. greater when this process is used. The *Alfa continuous butter-making process* eliminates the need for a churn. The cream is pasteurised and separated to give a butter-fat content of 78 per cent. This rich substance is cooled in a three-cylinder apparatus. The cream emerges from the lowest cylinder at a temperature of 68° F., later emerging from the middle cylinder in the form of a viscous liquid at 48° F. to 50° F. It is warmed to 57° F. in the uppermost cylinder. It finally issues as an emulsion to flow into parchment-lined boxes. The product solidifies during cold storage as normal butter with no visible signs of free moisture and with a clean, fresh flavour which improves with keeping. The moisture content of butter manufactured in this way can be controlled within wide limits. Normal composition is 78 per cent. butter-fat, 2 per cent. non-fatty solids and 20 per cent. water. Plant capacity is in the region of 550 lb. of butter per hour. It is claimed that the keeping quality is improved owing to the uniform nature of the emulsion and the absence of any risk of contamination from the washing water or from the atmosphere.

In the *Fritz process* cream having a 45 per cent. fat content is pasteurised and cooled to between 45° F. and 50° F., according to desired firmness in the final product. The liquid is pumped into a cylinder, striking a baffle on entering. It is formed into a film on the inner surface, being struck by four horizontal blades which revolve at 3,000 revolutions per minute. Butter granules form, while the buttermilk is separated from the cream in ninety seconds. The butter is then pressed to remove the remaining buttermilk content. After a second compression it is ready for packing. Churning temperatures are in the region of 44° F. to 50° F., according to season. Control of the moisture content is adequate. Sweet cream is used. Some of the plants employed will produce up to 2 tons of butter per hour. Flavour and storage life are said to be satisfactory.

Washing and salting must be carried out when churning has been completed. The buttermilk is drained off, clean cold water being used to wash the butter granules so that all traces of buttermilk are removed. When the water has been added, the churn is revolved several times, extremes of temperature being carefully avoided. Over-washing must be guarded against, otherwise the aroma and flavour will be affected. After a final washing with water, the butter is sometimes washed with brine to impart a pleasing flavour, the grains being allowed to soak in the brine for fifteen minutes. If salt butter is desired, salt is usually added while the butter is in the grain prior to working. For mild salt butter ¼ ounce of salt per pound is added, with ½ ounce per pound for the medium salt variety. Only the purest fine, dry clean salt should be used. The working process subsequently incorporates the salt into the mass. The working of the butter should not be completed in one operation, the salt being given time to dissolve. If this is not done a streaky product will result. Dry-salted butter will keep better than butter treated with brine.

Thorough *working* is essential, although the pressure applied should not be sufficient to injure the grain. The objects of the working process are : (*a*) to render the butter compact, (*b*) to remove any surplus buttermilk which may still be present, (*c*) to distribute the moisture, which must not be more than 16 per cent. in the final product, and (*d*) to incorporate any salt which has been added. In farm-house production a separate worker is used. This consists of a fluted wooden roller fixed to a table, under which the butter is passed backwards and forwards. In butter factories the product is generally worked in the churn. The legal moisture content must not be exceeded, although the limit should be closely approached if maximum profit is to accrue. The correct extent of working required is a matter of experience. Excesses in either direction affect the body and texture of the finished article. Over-worked butter is sticky ; under-working causes leaky butter of uneven texture containing an excess of free moisture. The presence of excess moisture can readily be detected by cutting a ½-lb. block, when any excess will exude from the broken sections.

Making-up and wrapping into ½- and 1-lb. blocks usually follows, the sales value being enhanced by neat moulding and attractive wrapping. A moulding and wrapping machine is employed for this purpose. The quality of the wrapping paper is important, representing as it does a possible source of serious contamination. Only the best-quality vegetable parchment paper should be used, the so-called greaseproof paper being cheaper but not so suitable. Vegetable parchment papers should not support mould growth, while paper which is brittle and exhibits a hard texture should be rejected. Wrapping papers should be protected from dust during storage to prevent contamination by bacteria, moulds and yeasts. Wrappers may be sterilised by soaking in brine solution or by boiling in water. Butter in bulk is usually packed in fibre-board boxes or in wooden boxes or tubs. Wooden containers are often sprayed internally with paraffin wax to seal the pores and to provide a smooth clean surface. Wood or timber taints may be avoided if internal surfaces are treated with casein, which is afterwards hardened by means of formaldehyde vapour. Parchment linings should be chosen with care. No pockets in which moulds may develop should be left during packing. After it has been packed, butter should be cold stored. This will permit of hardening before despatch.

Premises

The premises in which butter is manufactured should be constructed on creamery lines, their design, planning and other details being equally important. The essentials are : (*a*) sanitary construction with ease of cleansing, (*b*) an adequate pure water supply, (*c*) sufficient natural and artificial lighting, (*d*) provision of steam for pasteurisation and sterilisation, and (*e*) suitable storage accommodation for raw materials and for the finished article. The *aspect* should preferably be such that all windows face in a northerly direction. The *size* of the premises should be sufficient to provide maximum space with facilities for easy working and cleansing. All *windows* through which the sun is likely to gain entrance should be glazed with tinted glass to exclude direct rays. A large volume of *water* will be required. It is therefore essential that the supply should be both adequate and pure. Any contamination of water used for butter-making may be dangerous, will reduce keeping quality and will cause poor flavour. The cream-ripening room should be kept entirely separate from the remainder of the building, as the cream may have to ripen here for varying periods during which it is open to atmospheric contamination. For this reason the room should not be used for any other purpose. Arrangements should be made to control the temperature of this room during the ripening process, some form of heating apparatus usually being required. Processing rooms should adjoin the ripening room. Provision should be made for storing the salt and also the cleansed and sterilised utensils. The premises should be so planned that the milk passes into the premises at one end and leaves at the other end in the form of butter, the processes being arranged in consecutive stages.

Cleansing of Plant

When operations have been completed, the apparatus and various utensils must be thoroughly cleansed and sterilised. They should be well washed with cold water, followed by very hot water which contains a suitable detergent, hard scrubbing being necessary to remove grease. Sterilisation with either steam or chlorine solutions should follow. The need for proper cleansing and sterilisation cannot be too often emphasised. The treatment of the cream separator is particularly important. If this apparatus is allowed to stand in a dirty condition until required for further use, traces of milk or cream will remain in the bowl or upon the discs. The bacteria which will grow will then inoculate the next batch of liquid passing through. If clean milk is passed through an unwashed separator, the cream is likely to sour quickly. Dismantling and proper scrubbing of the various portions of the apparatus should be undertaken as soon as treatment has been completed. Sterilisation should commence when washing has finished, chlorine solutions being frequently used as an additional safeguard. Churns should be well scrubbed with hot water and detergent to remove all traces of fat. If this is not done a " sticky churn " will result, due to the fat residues forming a surface to which the fat in the butter will adhere during subsequent use. If the wooden surface is perfectly clean, no adherence will occur. Scalding or treatment with chlorine solutions should follow, after which the apparatus should be allowed to dry. To prevent the entrance of dust, the churn opening should be covered or the churn inverted. In dealing with cleansing and sterilisation of the churn the workers should not be overlooked. Utensils in which " starter " is stored and manufactured demand constant care if the " starter " is to remain pure for any length of time. After the apparatus has been dealt with, the internal surfaces of the premises should receive adequate attention. It should also be remembered that absolute cleanliness is essential at all times if butter of a suitable texture and quality, *and which can be regarded as safe,* is to be produced.

Grading

The big butter-exporting countries have adopted grading systems, the product being classified into various grades according to quality. *Flavour* is generally classified under the same heading as *aroma*, although these qualities are entirely different. If aroma only is judged the result may be deceptive, as flavour and keeping quality may be overlooked. The flavour of butter should be sweet and nutty, free from objectionable taints. Refrigeration assists in the elimination of plant flavours and will help to obviate deleterious flavour of other types. The quantity of salt added to butter should not be sufficient to destroy its natural flavour. *Colour* presents another problem, a clean straw colour being ideal, although different districts prefer different colours. A colour scale is usually employed as a standard guide. There are no restrictions relating to the use of colouring materials in butter, provided they are obtained from pure vegetable matter. Defective colours are almost invariably due to faults in manufacture. Excessive *moisture* will lose grading points, its percentage determination being only possible by means of chemical examination. Suitable *packing* enhances the sales value of butter, a badly-packed article containing air pockets which encourage the development of moulds. Butter is graded by means of a " trier." This is inserted at an angle throughout the full length of the mass, after which it is given a half turn and withdrawn. The butter removed is immediately tested by smell and taste. Grading usually takes place when the butter is two to three days old, as the flavours have then had sufficient time to develop.

Keeping Qualities

Butter has excellent keeping qualities, although the term must be viewed relatively, as butter will not maintain its original condition indefinitely. Unlike many foods, butter is not protected by a can. Even if this were so, the protection afforded would be of little assistance, as any bacteria present are distributed throughout the substance. Butter will keep for six to nine months without refrigeration, the main reason for its good keeping quality lying in its composition. Butter contains at least 80 per cent. of fat, with not more than 16 per cent. of moisture. The moisture is made up of the buttermilk which remains after working, together with water from the washing process, and is distributed throughout the substance in the form of small globules. Any bacteria present are enclosed in these minute droplets. Risk of infection is decreased if the droplets are reduced in size. This object may be achieved by continuous and thorough working of the butter. Over-working for the purpose of eliminating moisture is very harmful, as the texture suffers. If, however, butter is worked to the optimum limit, experiments have shown that bacterial decomposition is reduced by as much as 40 per cent. Butter is often spoiled owing to the presence of yeasts and moulds, particularly as ripe moulds may be carried to any part of the manufacturing premises by draughts. *Oidium lactis* is a common inhabitant of creameries and will grow almost anywhere in the presence of moisture. The acid of sour cream is acted upon by the lecithin in the butter, producing a fishy flavour. This process is accelerated in the presence of metals, traces of which can scarcely be avoided. It must also be remembered that cream following pasteurisation has lost most of its bacterial content and can be quickly recontaminated. When manufactured, butter usually contains not less than 10,000 organisms per millilitre. As it is not sterilised after manufacture or packed in airtight containers, the keeping quality of butter is excellent having due regard to these facts. Unsalted butter exhibits the best keeping qualities.

Flavour Faults

Butter may exhibit a variety of taints due to improper handling of raw materials or the finished article. *Sourness* is generally caused by excessive acidity in the cream prior to churning. *Bitterness* may be due either to feeding-stuffs or to ripening the cream at too low a temperature. Coliform and mould contaminations will produce this taint, as will impure or excess salt and impure water. *Food taints* are caused by the inclusion of excess quantities of certain foods such as roots, silage or highly-flavoured concentrates, as well as weeds, in the rations of milk-producing animals. Where such taints develop, the feeding-stuffs should be investigated with a view to eliminating the source. Aeration of the milk and cream over a surface cooler is beneficial, many volatile food taints being dissipated in this manner. Quick ripening of the cream is also of assistance, as is frequent ventilation of the churn. Milk, cream or butter will absorb offensive or unpleasant odours when allowed to stand in close proximity to strong-smelling articles. The vacuum pasteurisation process is of considerably assistance in reducing food taints in cream. *Staleness* is often met with during hot, sultry weather, and may be due to poor-quality cream or to the storage of butter at various degrees of temperature. *Rancidity*, which can be considered as the final stage of staleness, results from the decomposition of the butter-fat into glycerine and fatty acids, and to oxidation. Rancidity and moulds are closely allied and are evidence of advanced deterioration of the product. If butter has an *insipid taste*, the flavour is somewhat similar to that of margarine. Insufficiently-ripened cream, the feeding of rank herbage to dairy cattle and over-washing the butter are the commonest causes. There is nothing objectionable about such an article, but if the insipidity follows the churning of sweet cream rancidity may result. "*Flat*" *flavour* is sometimes caused by excessive cold storage and also occurs in butter produced from neutralised cream. The flavour of normal butter is improved by the addition of salt. *Tallowy* flavour is particularly objectionable. This is a permanent defect, the texture of the butter suffering. Certain bacteria derived from grass may cause this defect, as will the presence of copper salts. Cream stored for too lengthy a period may also be responsible, as well as over-ripe cream which has been rapidly heated or cooled. Cream from the milk of cows fed on watery herbage or cream exposed to bright sunlight can produce a similar effect. Butter which tends to be tallowy will show a pronounced flavour following alternate heating and cooling. Great care must be taken in churning thick cream and working the butter made therefrom. *Fishiness* develops sometimes, chiefly in salted butter, the two main causes being highly acid cream and high temperatures in the cream or butter. The mould, *Oidium lactis*, which makes its home in the woodwork of dairies, will produce this defect. Suspected woodwork should therefore be treated with hot lime wash.

Butter should be well worked when salt is added. *Saltiness* may otherwise occur, particularly in "leaking" butter. Cream which has been improperly pasteurised at too high temperatures will impart a *scalded taste* to the product, this defect being most noticeable when the temperature of the butter is raised. A *heated taste* is often observed in insipid butter and is due to exposure of the product to high temperatures. This flavour is quite distinct to the scalded taste previously mentioned. A *wooden taste* may develop, due to the activities of certain yeasts or to direct contact with wooden containers. Careful tests of the butter packed in such containers should be made if this latter source is suspected. *Oiliness* may be due either to vegetable or mineral contamination. This taint may also arise from decomposition of butter-fat. *Cheesiness* is due to the use of old heated cream and to inefficient cleansing and sterilisation of cream containers. Any traces of cream left in the ripening vats will become " cheesy," each fresh supply of cream coming into contact with such traces being inoculated with the causative organisms. High-fat cream may cause cheesiness in the resultant butter. When the butter is exposed to high temperatures this flavour becomes more pronounced.

Faults in Appearance

Several factors are involved in the faulty appearance of butter. *Faulty colour* may be due to several causes. It must be remembered, however, that colour is often a matter of personal choice. The deep colour of Danish butter is generally preferred in our northern counties, the pale-coloured product being popular in southern England. The milk from cattle of certain breeds may be pale in colour, while the feeding of excessive quantities of cake and roots may result in the milk having a pale-coloured butter-fat. This is reflected in the butter manufactured from such milk. The over-working of butter will produce a decrease in colour intensity, as will exposure of the cream or butter to strong daylight. Annatto is often used to improve the colour of naturally pale butters. An *irregular colour* is sometimes observed. This is due to lack of care in working, to variations in the consistency of the finished product, or to differences in the butter-fat content of the cream used in manufacture. This defect may also occur as the result of mixing several churnings prior to working. *Discolorations* may occur due to moulds and also to bacteria of the *Pseudomonas* species. *Streakiness*, a highly undesirable defect, is generally due to inefficient washing of the product while in the grain, or to over-working. Lack of care in salting and the use of low-grade salt will also cause this defect, which has tended to increase during recent years following the use of modern methods of butter working.

A *mottled appearance* is due to the use of unevenly ripened cream. Low-density cream will occasionally separate when allowed to stand, and will coagulate in the bottom of the ripening vat. The particles of casein are broken up when the vat is emptied, the cream becoming more finely divided on churning. The resultant butter shows small white specks in the bulk, which may also be present following the pasteurisation of over-ripened cream. " *Leaking* " *butter* contains a high moisture content. Leakage of this moisture may cause loss of weight. Some butters are naturally moist and show an appreciable degree of free moisture without any signs of serious shrinkage. Such butters should not be confused with " leaking " butter. " Leaking " is caused by churning cream at excessive temperatures, churning too much cream at one time, under-working the butter, storage at too low temperatures and the use of too much salt. *Poor texture* may be produced in a variety of ways. A granular condition may result from the churning of improperly-cooled cream. Under-working butter results in a loose, open texture, while butter is occasionally " weak bodied," exhibiting lack of solidity. A hard-textured butter occasionally possesses a low moisture content. The type of feeding-stuff and period of lactation of the cow each play a part in determining final texture. A fatty texture is produced by soft butter-fats, heated cream and high churning temperatures. The condition increases as the butter ages. Over-working will damage the texture, while under-working will cause the texture to be poor. *Yeasts and moulds* produce harmful changes in butter. A *musty taste* is associated with these organisms, which readily gain access to milk or cream. Old churns and butter workers are particularly liable to heavy contamination. The production of butter from raw cream may cause this defect, especially if the product is subjected to varying temperatures or is stored in a damp, badly-ventilated atmosphere. Parchment wrapping papers and salt, if not of sufficiently high quality, may also be responsible. The use of unseasoned and contaminated wood for containers may further affect butter. Parchment wrappers of good quality should be inserted between the butter and wooden surfaces. Yeasts and moulds flourish at temperatures in the region of 57° F. but will grow at much lower temperatures. Black or white mould growth due to contamination in cold stores may occur ; such moulds may penetrate the mass of butter and produce rancidity. All wooden and metal utensils should be efficiently cleansed and regularly sterilised to prevent mould development. Dirty methods of manufacture and laxity in sterilisation are incentives to their growth.

Butter Blending

There is a demand for blended butter in this country. Much of the butter now on sale is blended, different grades of home-produced, colonial and foreign butters being mixed together. This process does not improve the final product, as it destroys both texture and grain. It does, however, make possible a uniform article which is easy to spread. The blending process is carried out in a machine fitted with revolving blades which knead the various batches of butter together. During the process additional moisture may be incorporated into the mass. A dry butter with a low moisture content may thus be brought almost to the legal limit of 16 per cent. moisture. Certain types of butter-moulding machines may cause a serious loss of moisture, although this loss is usually avoided by the incorporation of additional moisture. Care and cleanliness are essential in carrying out the blending process, otherwise the bacterial content may be greatly increased, with consequent deterioration of the final product.

Dehydrated Butter

During the War difficulties involved in transporting large quantities of butter from New Zealand caused investigation to be carried out into methods of extracting dry butter-fat and packing the fat into suitable containers so that it could be easily transported without rapid deterioration. It was already known that, while the nutritive properties of the substance were preserved, the natural characteristics were lost during processing. Unsalted butter possessing a low moisture content is melted by steam. Part of the serum and solids-not-fat content are separated out by gravity in a special cylinder, the fat being recovered from the serum by means of a small separator. The bulk of the liquid fat is pasteurised and passes to a supply tank, from which it travels to two further separators fixed in series, its final moisture content being reduced to between 1 and 2 per cent. The fat is then dehydrated, all further moisture being removed. It is finally cooled and filled into cans which are sealed ready for export.

Milk-blended Butter

There is little sale for this type of butter in Great Britain at the present time. Milk-blended butter is manufactured from imported butter into which an additional quantity of milk has been worked. Milk-blended butter must not contain more than 24 per cent. of moisture and may only be designated by descriptions approved by the Ministry of Agriculture and Fisheries. The presence of such an excessive moisture content seriously interferes with the keeping quality of the article. Only milk which is perfectly clean and safe should be used for blending purposes.

Renovated Butter

Many countries treat butter which is unfit for human consumption by a renovation process. This is said to render the butter fit for use. The fat is melted and the curd removed by sedimentation, air being blown through the liquid to disperse any offensive odours which may be present. The whole is then emulsified by churning with milk and it is subsequently worked and washed as in ordinary butter manufacture. "Neutroxyd," which consists chiefly of magnesia combined with small quantities of carbonate and silicate, is sometimes employed for renovation purposes. Rancid butter may also be sweetened by working it up with water containing chlorinated lime or sodium bicarbonate. When examined by means of polarised light, renovated butter exhibits a blue field mottled with yellow.

Canned Butter

As a further development of the Alfa process already outlined on p. 195, canned butter conserve with a fat content of 80 per cent. has been prepared. Hot cream containing this fat percentage and obtained from the Alfa process, and at temperatures between 140° F. and 158° F., is filled directly into metal cans, which are sealed and stored between 68° F. and 86° F. Cooling down to 104° F. must be rapid, but the temperature must never be allowed to fall below 68° F. After twenty-four hours' storage, the cans are placed in boiling water for two hours so that the cream in the centre of the can reaches a temperature of 185° F. to 194° F. The cans are then re-cooled. After a further twenty-four hours the heating and cooling process is repeated. The conserve is now allowed to cool to any desired temperature, being converted into butter in four to eight days at 50° F., or in six weeks at 68° F. If poor-quality milk is delivered from the farms, the canned product receives three separate heatings. Canned butter can be stored at low temperatures for lengthy periods, although some loss of original freshness is unavoidable.

Synthetic Butter

Imausen, in Germany, has produced synthetic butter by processing paraffin. The paraffin is first treated by oxidisation and is then heated to extract the fatty acids. A second distillation of the fatty acids is given, glycerin and carotene being added. One hundred tons of paraffin are said to yield 80 tons of fatty acids, from which in turn approximately 40 tons of synthetic butter can be produced. It is claimed that this type of butter can be consumed without harm by diabetics, since it contains no acetone.

Whey Butter

Whey, which is a by-product of cheese-making, contains varying proportions of butter-fat. Separation of this fat is often carried out. The whey is first passed through a high-speed separator of special type, all the fat being extracted. Immediate separation is required to prevent a cheesy flavour developing in the resultant butter. The cream is mixed with water and is churned in the ordinary manner, after which it is salted and worked. A thorough washing is required, otherwise a cheesy flavour will be noticeable. If the process is properly carried out an article of excellent quality, flavour and appearance will be produced. This type of butter is usually pale in colour, so that a small quantity of colouring matter is often added. Large quantities of whey butter are imported into this country for use by confectioners.

Buttermilk

Buttermilk, a most important by-product of the butter-making industry, is much more easily digested than is cows' milk, owing to its casein content being more finely divided. It also contains more iron in concentration. Buttermilk is little used in this country as an article of diet, such quantities as are available generally being used for pig feeding. Small quantities are manufactured into buttermilk cheese. Buttermilk is, however, a staple beverage in many countries. In these countries it is considered to possess valuable remedial properties, being used for the treatment of rheumatism and pulmonary infections. An exclusive buttermilk diet has been used with advantage in the treatment of kidney diseases, while gastric acidity may be effectively counteracted by its consumption. Buttermilk has a full flavour and body, the flavour being due to the acidity present and to those constituents responsible for the flavour and aroma of butter. The finely-divided precipitated casein in suspension is responsible for the body. Any particles of butter-fat which may be present will improve the flavour. In America buttermilk is artificially manufactured on a large scale, being prepared from newly-separated milk which is artificially ripened at 70° F.

Composition

The *composition* of butter depends upon the principles and practice of manufacture. Butter normally contains approximately 82·5 per cent. butter-fat, an average of 12 per cent. moisture in the form of water and smaller quantities of casein, lactose and mineral salts. Butter-fat contains butyric, caproic, caprylic and capric acids, which, as they are soluble in water, are known as the soluble fatty acids. Butter also contains fatty acids which are insoluble in water. These are myristic, palmitic, stearic and oleic acids. Small quantities of lauric, arachidic and dioxystearic acids may also be present. The percentage of soluble volatile acids in the butter-fat serves to distinguish it from other animal and vegetable fats.

The *colour* of butter varies from white to deep yellow, while it is more or less granular in character. The natural colouring matter is *carotene*. There is at present no available means of distinguishing between natural and added carotene. Colour depends to a considerable extent upon the diet of the cows. On spring and summer pastures increased quantities of carotene and xanthophyll are available. Winter butter is usually pale in colour, artificial colouring matter being often added. This practice is undesirable, and the buyer may thereby be deceived. The quantity of colouring matter added is usually in the neighbourhood of 1 ounce to each 100 lb. of cream. The addition of artificial colouring agents has decreased within recent years, light-coloured butters being now generally preferred. Colour will fade following prolonged exposure to light. No preservatives may be added to butter although the incorporation of common salt is permitted.

Butter has a characteristic *flavour* which is produced naturally. The depth of flavour can be controlled by the degree of acidity to which the cream is ripened previous to setting and churning. The flavour of butter improves up to a period of forty-eight hours after production. The *keeping quality* of butter depends upon its casein content, being also influenced by bacteriological and chemical deterioration. Butter manufactured from sour milk or cream has a high casein content. This affects the keeping quality and encourages rancidity, especially if buttermilk has not been properly eliminated during manufacture.

Chemical oxidation of the fat occurs rapidly under acid conditions and is accelerated by high temperatures and by the presence of traces of copper. Bacteriological rancidity is due to the lipolytic decomposition of the fat content. This change is rarely related to the number of organisms present, but depends upon the activity of certain species, the most potent being the lipolytic bacteria, coliform organisms, with certain moulds and yeasts. Bacterial growth is readily suppressed by salting, although highly-salted butter is not popular with consumers. Full flavour can seldom be combined with long keeping quality in cold storage. All butter has a definite *aroma*, some types being richer in this respect than others. The aroma, which may be simulated in butter substitutes by artificial additions, owes its origin to *diacetyl*, formed after fermentation by certain types of lactic-acid organisms. This substance, which can be artificially prepared, is often added to low-grade butter to improve the aroma. Excessive additions will produce acidity. The less diacetyl is contained in butter the longer will it keep. Diacetyl is said to exert a detrimental effect upon the vitamin A content. The detection of added diacetyl is difficult because of variations in the quantity present under normal conditions.

Nutritive Value

Butter is among the most palatable milk products, being easily assimilable. Its food value has hitherto been insufficiently recognised. The need for the consumption of more butter as soon as conditions improve cannot be too strongly emphasised, the butter ration requiring to be at least double the pre-war average. Butter is the most concentrated of all dairy foods. One pound of butter contains as much butter-fat as 25 to 30 lb. of fresh milk, its calorific value being approximately 3,300 calories per pound. The annual consumption of 15½ lb. of butter per head in 1939, giving a weekly consumption of 5½ ounces, compared unfavourably with the approximate annual consumption of 37 lb. per head in New Zealand and other butter-producing countries.

Butter forms one of the most easily and completely digested fats and is an excellent source of vitamins A and D. The vitamin A and B content is higher in summer than in winter butter. Loss of vitamins is slight during storage at temperatures of 10° F. and below. Pasture-fed butter is said to contain approximately twice the quantity of vitamins A, D and E than does dry-fed butter-fat. School children whose diet included additional butter have shown individual increases in height and weight appreciably above those of children supplied with a normal diet. Butter-fat, which is easily assimilated, gives a high calorie yield in compact form, providing twice as many calories per gramme as do proteins and carbohydrates.

Bacteria in Butter

Lactic-acid organisms play an important part in butter manufacture, and also in its spoilage. In good-quality butter which has been properly manufactured these organisms can obtain little nourishment other than that obtained from the fat although the product is not secure from attacks by yeasts and moulds. Any source of nourishment is, however, readily attacked and utilised by these organisms, which form acid by-products. Most of the bacteria present in butter are of the *non-pathogenic type*, although butter produced from unpasteurised cream will contain organisms similar to those present in the milk from which the cream has been obtained. Yeasts and moulds may also be found together with coliform organisms. As the temperature rises they multiply rapidly. These non-pathogenic types have little public health significance but, as they may cause rancidity and reduce the keeping quality of the product, their presence is undesirable. In butter produced from pasteurised cream *Streptococcus lactis* is most commonly found, although certain heat-resistant types may be present. These organisms do not exist for any lengthy period, being gradually replaced by other lactic-acid types and by yeasts. The bacteria present usually develop in the small droplets of moisture contained in the substance. The bacterial content of sweet-cream butter increases for the first few days after production, after which it decreases. In butter produced from ripened cream the total count is highest immediately after manufacture. This is explained by the fact that lactic-acid organisms are destroyed more rapidly than their successors can develop, since the nutritive matter available for their growth is constantly decreasing. Organisms grow more rapidly in sweet-cream butter than in that manufactured from ripened cream to which salt has been added. While promoting the growth of yeasts and moulds, lactic-acid organisms partially inhibit the fat-hydrolysing organisms which cause rancidity. Any artificial cultures employed should be pure, otherwise undesirable organisms may gain entrance to the cream after pasteurisation.

Butter manufactured from unpasteurised cream may contain any of the *pathogenic organisms* present in the milk prior to its separation. The most important of these is *Mycobacterium tuberculosis*. Savage has stated that up to 10 per cent. of English butter may be contaminated with *M. tuberculosis*, which can survive for lengthy periods, as may also *Brucella abortus*. Outbreaks of typhoid fever have been reported due to butter. It can be presumed that the causative organisms gained entrance to the milk, cream or butter *after* production. Typhoid bacilli may survive several days in salted butter, and have been isolated from the unsalted variety after several months' storage. *Corynebacterium diphtheriæ* does not normally survive in butter for lengthy periods, although one outbreak of diphtheria attributed to butter has been recorded. When present, food poisoning organisms may survive for many weeks. Defects in butter affecting the appearance and taste of the product have already received attention on pp. 199 to 201. It will be sufficient to state once again that many such defects are due to *abnormal bacteria*, particularly yeasts and moulds. Contamination by organisms of the pathogenic or abnormal types can be prevented if sufficient care is exercised during churning, handling and packing of the product.

The *sources of bacterial contamination* in butter are numerous. The *raw milk supply*, particularly in the case of butter manufactured from unpasteurised cream, can add all types of organisms to the finished product. The importance of efficient pasteurisation of the cream after separation cannot be over-emphasised. Although *salt* is normally regarded as a safe preservative, it is not always free from bacterial impurities, especially if packed or transported in unsuitable containers or improperly stored. Salt cannot be cleansed before use, so that a guarantee of purity, together with suitable storage prior to use, is essential. Poor-quality *packing materials*, particularly wrappers which come into direct contact with the butter, together with wooden or cardboard containers, also increase the bacterial content. Only the highest-quality materials should therefore be employed. The *water supply* may be contaminated, particularly in country districts. The possibility of *atmospheric pollution* is often overlooked. Air conditioning, while satisfactory, is expensive. Expense in this matter, however, represents an actual economy, as air-borne contamination may be responsible for poor quality in the final product. The condition of *premises, plant and utensils* is of major importance. Constant unvarying cleanliness in all stages of manufacture is vitally necessary. Metal containers should be constructed of suitable materials which are not likely to taint the product and which can be easily cleansed. Proper storage of such articles after sterilisation should not be overlooked. Accumulations on floors, walls or ceilings form possible sources of contamination. Metal-topped tables should be used wherever possible, wooden surfaces being limited to an absolute minimum. Contamination from *personnel* may also occur. Employees should be medically examined at frequent intervals, regular health supervision being maintained as a routine. Cases of illness in the homes of employees should be notified ; the hands of employees who are in contact either with the raw materials or the finished product should be regularly inspected. Employees should be required to use the washing accommodation provided ; this should be adequate. Employees should wear clean overalls and head coverings at all times.

Epidemiology

Very few outbreaks of disease have been traced to the consumption of butter. An outbreak of *typhoid fever* was reported during 1917 from the United States, seven cases being notified. Butter produced from unpasteurised cream on a farm was the cause of the outbreak. Another outbreak in the United States affected ten persons. Here again the butter had been made from unpasteurised cream. Outbreaks due to the infection of butter by " carriers " have also been reported. An outbreak of typhoid fever traced to blended butter supplied by one retailer occurred in Paris in 1944, 922 cases being reported. The organisms of *bovine tuberculosis* and *contagious abortion* have been isolated from butter bought in the ordinary manner. These organisms have survived storage for several months. An outbreak of *food poisoning* due to the consumption of infected butter has also been reported, *Staphylococcus aureus* being the causative organism. An outbreak of *diphtheria* due to a " carrier " working on a farm where butter was being produced has also been recorded.

Control

The control of butter manufacture and distribution is based upon the terms of the Food and Drugs Act, 1938. As with all other foodstuffs, processing and distribution call for constant supervision, particularly as this relates to the quality of the original milk, the methods of pasteurisation used, handling and the health of personnel. In addition to the normal *bacteriological examinations* for total bacterial content, butter is examined for presence of yeasts and moulds, which can exert a harmful effect upon the substance. The detection of pathogenic organisms may also be necessary on occasion. *Chemical examinations* are important, not only as regards the salt and moisture content but also for the detection of adulteration, the addition of colouring matter and the presence of preservatives. Butter has often been found adulterated by the addition of foreign fats such as coconut oil or margarine, and by the incorporation of excessive quantities of salt, water or preservatives. The addition of these latter substances to butter is illegal, while the quantity of moisture which it may contain is limited to 16 per cent. of the whole. Casein and starch have also been used as adulterants, the former as a scientific addition, the latter presumably as a drier.

Margarine

Margarine was first exhibited to the public, in Paris, in 1869. During the siege of Paris it was developed as a substitute for butter, being manufactured from stearin with the addition of a small quantity of vegetable oil. In those days margarine was often given the name " artificial butter," although it was perfectly white in colour. Margarine has increased in popularity as the years have passed, its value having been fully appreciated during the first and second World Wars, when it was of considerable assistance in remedying deficiencies in the fat ration.

Manufacture

Margarine was first prepared from beef and other animal fats. It is now produced by means of a refining process of fractional crystallisation and by careful pressing of the fat. Animal and vegetable fats are used. These are churned with skimmed or whole milk which has previously been pasteurised and ripened with an artificial culture. Modern methods of refining, plus increased knowledge relating to hydrogenisation, have enabled many vegetable and animal oils to be used in the production of margarine. Modern margarine manufacture demands careful chemical and physical control, as the melting points, hardness and texture of the blended fats must be carefully regulated if the final product is to possess the consistency of butter. Margarine is now prepared by churning melted or clarified animal or vegetable fats with milk ingredients. Beef and mutton fats or lard are employed, together with deodorised and hardened whale oil. Cotton-seed, sesame, palm kernel and coconut oils, which may or may not be hardened are among the vegetable oils used. By the addition of skimmed or whole milk the curd or casein of margarine acquires a flavour very similar to that of butter. Margarine which contains animal fat is considered to be more nutritious than that composed solely of vegetable oils.

Most margarine is enriched with vitamins A and D and is often coloured by the use of annatto, the final product being scarcely distinguishable from butter either by appearance, taste or smell. The mixture of fats is varied according to season. The fats are melted and blended thoroughly in jacketed pans fitted with mechanical agitators. Fresh cooled, separated milk of the required acidity is churned with the mixture of fats in cylindrical churns which have refrigerated jackets, the ingredients being thoroughly kneaded into a homogeneous mass. The churn has a revolving core which operates within the jacket, the materials being forced along definite channels until a homogenous mass is delivered at the front of the churn. This mass is decanted into receiving vats. The product is then worked to impart proper texture and to knead out excess moisture, after which it is removed to cold storage, where it is hardened to the required consistency prior to packing into small blocks or boxes. Sanitary care in handling during all stages of processing and subsequent treatment is essential. Many modern factories are air-conditioned to eliminate the possibility of bacterial or mould infection, which would affect the final quality of the product. Care of apparatus, which should include cleansing and sterilisation, calls for scrupulous attention, as does supervision of personnel.

Composition

The composition of margarine resembles that of butter. Its fat percentage is similar, although the moisture and curd contents are slightly higher. The salt content is considerably lower, as none of this substance is mixed with the ingredients. The oils used in manufacture differ from butter-fat in that they contain only traces of soluble volatile fatty acids, being for the most part composed of the glycerides of oleic, palmitic and stearic acids. The quantity of butter-fat in margarine is limited to 10 per cent. of the whole, while the moisture content, as in the case of butter, must not exceed 16 per cent. As an emergency measure, a maximum of 0·25 per cent. borax is at present allowed. This acts as a preservative. In Germany, manufacturers are required to add 10 per cent. sesame oil so that the product may be readily identified. Similar suggestions have been put forward in this country, while it has also been proposed that no artificial colouring matter should be allowed or that the colour should be distinct from that of butter. No action has yet been taken along these lines although comparable regulations exist in other countries.

Nutritive Value

The food value of margarine varies. When manufactured from animal fats, its nutritive value is high. When composed of vegetable oils only, the nutritive value is considerably less. In good-quality margarine the protein, fat content and calorific value are comparable to that of butter. Taste and flavour are undistinguishable so far as the average consumer is concerned. Owing to the frequent addition of vitamins A and D, the vitamin potency of margarine is high, the standard being maintained throughout the year. In the case of butter, the vitamin content may vary considerably with the season. Whether or not the demand for margarine will continue when cheap imported butter is once again available remains to be seen. It can, however, be stated that margarine has a definite food value and that it will probably remain in demand for culinary and similar purposes.

Control

Margarine must always be clearly and permanently labelled, particulars regarding such marking being set out in the Food and Drugs Act, 1938. Adulterants in the form of paraffin wax, added to improve consistency and texture, have been found in margarine, while starch has also been detected. As margarine is cheaper than butter, it is seldom adulterated. Margarine differs from butter in that it yields much less "soluble" fatty acids. This provides the most accurate means of differentiation. Margarine is richer in anti-oxidants and is not subject to rancidity and other defects. While adulteration is infrequent, fraudulent deception is often practised, margarine being served in lieu of butter in cafés and restaurants when bread and butter have been ordered. This fraud can be detected by the consumer, since butter spread on bread exhibits a glistening surface whereas margarine has a dull appearance.

CHAPTER XV

CHEESE

CHEESE has attained great popularity as an article of diet during the past fifty years. Its origin is ancient, the original reason for its manufacture presumably being a desire to retain the many valuable constituents of milk in permanent and marketable form. Originally milk was allowed to sour naturally. The whey was drained off and the curd dried and salted, this method of manufacture still being carried out in Eastern countries. It was later discovered that the curd would keep without drying and that, if allowed to ripen, the curd possessed additional and valuable properties. The production of cheese represents the most primitive form of dairying and was formerly the only way in which milk or its equivalent could be marketed on an extensive scale. As the liquid milk trade developed, cheese production was increasingly affected, particularly on the farm. At present the bulk of cheese produced in this country is factory-made, farm-house cheese-making being virtually extinct. Manufacture has not kept pace with demand, although supplies have been considerably restricted within recent years. In spite of this, large quantities of cheese are imported annually, particularly from the Dominions and from the United States of America. Cheese is chiefly manufactured in this country during the summer months, when milk is most plentiful. While from the farmers' point of view cheese-making is more profitable than butter-making, there appears to be little likelihood of any appreciable increase in the quantity of farm-house cheese produced, the sale of liquid milk showing a still greater profit.

Perfect co-operation of bacteria, yeasts and moulds is essential if good-quality cheese is to be produced. The milk must be ripened by the growth of lactic-acid organisms of various types, which are allowed to develop naturally or are encouraged by the use of artificial cultures. These organisms cause the milk to clot while in the curd. The acids which they form assist the ripening process and regulate the growth of other organisms. In the later stages of production various specific bacteria and moulds may be employed to complete the process. It has been authoritatively stated that there are more than 500 varieties of cheese in existence, while new types are continually being evolved. Commercially, however, only a small proportion of these varieties can be considered as distinct types, possessing characteristics and flavours peculiarly their own. In many cases the differences are so slight as to be almost negligible.

Types of Cheese

Cheese may be roughly divided into three main classes. These are cheeses made from whole milk (Cheddar), those made from skimmed milk (Dutch) and those made from milk to which cream has been added (Stilton). A further sub-division is based on appearance and consistency. The *hard cheeses*, of which Cheddar, Cheshire, Lancashire, Gloucester and Caerphilly varieties are examples, have a relatively low moisture content, the mass ripening in a uniform manner. The growth and action of extraneous organisms is very largely inhibited, with the result that these cheeses possess excellent keeping qualities. Stilton, Wensleydale and Gorgonzola are examples of the *blue-veined varieties*, which have a high moisture content and a soft curd. These varieties are not only ripened by the normal organisms but also by the growth of moulds throughout their substance. *Soft cheeses*, such as Cambridge, Camembert, Parmesan, Limburger and Bondon types, have been the prerogative of continental countries for many years. They are extremely palatable and, owing to their high moisture content, the yield of curd per gallon of milk is high. This type of cheese is not pressed, the curd being allowed to drain naturally. They are quickly ripened. Two *special varieties* of cheese are also produced, *cream cheese* and the *pasteurised or crustless variety*. Both types are extremely palatable and of soft consistency, finding a ready sale in this and other countries.

Cheese Manufacture

The process of cheese-making varies in many details, in accordance with the variety of cheese manufactured. The general principles, however, remain the same. The object of cheese-making is to coagulate the milk solids in such a manner as will enable them to be compressed, stored and transported with ease, while retaining all the nutritive values of the original milk. The *milk supply* is important, cleanliness of the supply being a vital factor. An entire batch of cheese may be ruined by the presence of undesirable organisms which may produce gas or result in harmful fermentations. Milk used for cheese manufacture should always be produced under hygienic conditions from healthy cows. Its treatment and storage prior to use is also significant. The milk should be cooled quickly after production, to prevent bacterial development. Much cheese is now manufactured from pasteurised milk, a method which is not possible on the farm. Pasteurised-milk cheese ripens more slowly and develops a milder flavour, but has longer keeping quality and yields a more uniform product. The high-temperature short-time method of pasteurisation is usually preferred, the low-temperature method often resulting in a crumbly cheese which has a soft curd. The yield of cheese from a given quantity of milk is increased when pasteurised milk is used, probably due to coagulation of the albumin, precipitation of casein salts and greater humidity of the cheese. The whey of cheese produced from pasteurised milk contains no pathogenic organisms and can be safely used for animal feeding, while the organisms of animal diseases will also be absent. Fresh raw milk is required for the production of certain varieties of cheese. Control of the bacterial content is not always possible in such circumstances.

All milk should be tested on arrival at the factory by means of the *Wisconsin curd test* in addition to resazurin and fermentation tests. The Wisconsin curd test ensures that the milk is sufficiently clean and free from any defects likely to affect the subsequent curd. Unsuitable milk is rejected. The curd produced from milk containing large numbers of coliform organisms will possess an unpleasant flavour ; gas bubbles will be noticeable in the substance. Putrefactive bacteria in the milk produce a curd with a most unpleasant odour. The yield of cheese from a given quantity of milk depends upon the amount of fat and casein contained. The milk should be cooled upon arrival at the factory.

The first treatment consists of *ripening* the milk. This process takes place in the cheese vat. This is made up of a wooden outer skin with a suitable metal inner container, the space between the two layers being required for the admission of the steam and water used in the heating process. Capacities vary from 100 to 1,000 gallons. The milk is admitted to the vat and is thoroughly stirred. Ripening is dependent upon bacterial action, the particular flavour developed being in turn governed by the organisms present. Each species of cheese produces chemical bodies which impart the peculiar characteristics applicable to the brand. The ripening process may be carried out by allowing a natural acidity to develop, using a naturally-prepared " starter " inoculated into clean milk, the clotted milk being tested before it is added to the bulk. An artificial ripening culture propagated in pasteurised milk may also be used. Ripening increases the acidity of the liquid and assists in producing a suitable flavour. Artificial " starters " are preferable, being purer, more vigorous and better able to overcome any injurious organisms present in the milk. Such " starters " are prepared daily from clean freshly-pasteurised milk to which the " starter " has been added, the whole being thoroughly mixed. The culture must be maintained during storage at temperatures between 60° F. and 70° F., otherwise the organisms will not develop at sufficient speed. High temperatures must be avoided. If the " starter " forms a firm curd, the organisms are not sufficiently active. The production of excessive acidity destroys the " starter," which may then have to be prepared daily. When ready for use the " starter " is curdled into an even mass and should possess a smooth creamy appearance, have a clean acid taste and show, on test, that approximately 0·7 to 0·8 per cent. lactic acid is present. A small quantity of " starter " is usually retained for the production of a new supply. An increased quantity is added to the liquid when very sweet milk is used or when the liquid is slightly tainted, during cold weather, when small quantities of milk are available, or when rapid cheese production is necessary. When large quantities of milk are used, when the weather is warm or when milk is already acid, the quantity used can be decreased. Stilton and Wensleydale cheeses are often manufactured without the addition of a " starter."

The milk should be properly ripened before rennet is added, as the action of this substance is aided by the acidity of the milk. If a large quantity of " starter " is added immediately before renneting takes place, a thick granular curd will be produced, the resultant cheese being soft and crumbly, with an inferior flavour. The milk should be retained at a temperature suitable for the growth of lactic-acid organisms. The " starter " should be carefully strained into the milk in the vat and thoroughly mixed. Slow " starter " outbreaks have frequently been experienced in recent years, the lactic-acid organisms failing to produce acidity. This has been mainly due to bacteriophage infection of the " starter," although the use of penicillin in the case of animal diseases such as mastitis may also have an effect. To prevent this happening, the " starter " must be aseptically propagated in a separate room. " Starters " may suffer from (*a*) *over-ripeness*, due to the ultra-rapid development of acidity ; (*b*) *gassiness*, caused by contamination of the milk ; (*c*) *yeastiness*, with the development of a yeasty flavour and odour, and the production of gas ; and (*d*) *mouldiness*, due to the use of old or over-ripe " starters." If colouring matter is required, annatto is usually added during the ripening process, being stirred into the milk to secure an even tint. One-half to 3 ounces for each 100 lb. of milk is required, according to the final colour desired. The actual degree of acidity present must be estimated. Experienced workers are said to be able to perform this task by smell and taste. If a uniform quality is desired, however, either the acidimeter or rennet tests, both of which are standardised, must be used.

Renneting, i.e. coagulation of the milk, is brought about by the addition of rennet. Without this substance cheese-making would be virtually impossible. When rennet is added to milk, clotting takes place. A curd is formed and whey is liberated, the protein being broken down during the ripening process. Rennet is usually prepared from the fourth stomach of the calf and is a combination of several ferments or enzymes. These are rennin, which rapidly clots the milk and digests the protein, pepsin, which has a similar but weaker action, and rennet peptidases, whose action is not yet completely understood. Cheese-makers formerly manufactured their own rennet. As no two supplies were identical, the manufacture of cheese of uniform quality became a matter of chance. The Danish chemist Hansen first introduced a satisfactory extract of rennet, which possessed good keeping qualities and was of uniform strength. This resulted in considerable improvement in the final quality of cheese.

Rennet may be synthetically prepared in the laboratory. The product is a pure clear liquid of uniform strength. One part of rennet, which should be free from organisms capable of producing faults in cheese, is sufficient to clot 5,000,000 parts of milk. The action of rennet does not cease with coagulation of the milk and the contraction of the casein, being continued in the cheese and resulting in the formation of soluble proteins. Ripening is accelerated if the quantity of rennet is increased. Only good-quality rennet should be used for coagulation purposes. It should not be stored for lengthy periods before use, although moderate storage in a cool place will assist in preservation. It should possess low pepsin content and be of uniform strength.

When the milk has been sufficiently ripened, it is warmed by the circulation of hot water in the water jacket of the vat, the temperature at which renneting takes place and the quantity of rennet required varying according to the type of cheese to be made. This in turn is influenced by the acidity, the temperature and composition of the milk and the strength of the rennet. Rennet is usually tested before being added to milk. The process of renneting is carried out at a temperature of 80° F. to 91° F., some 2½ to 4 ounces being required to coagulate 1,000 lb. of milk. The acidity of the milk, the renneting temperature and the quantity of rennet added are so regulated that the curd is ready for cutting within a specified time. Soft cheeses are set at lower temperatures, less rennet being used. Rennet is usually diluted with cold water to several times its volume before being added to milk. After the rennet has been added, stirring takes place to ensure its thorough distribution throughout the bulk. Over-stirring should be avoided, as a broken curd will result. Gentle stirring of the surface must be continued to prevent the cream rising before coagulation begins, this being determined by flicking the milk with the finger. If bubbles remain on the surface, coagulation has begun. Stirring should then cease, the vat being covered to prevent the curd being chilled. If this is not done a weak curd will result. The mass is finally left until the curd becomes firm.

Preparation of the curd is an important matter. When the curd is compact and firm, it is cut into cubes by means of a special knife which has several blades, some of which cross the others, so that cubes of uniform size are produced. To determine its readiness for cutting, the curd is tested by inserting a finger and lifting upwards through the mass. A clean break with the liberation of clear whey denotes that the curd has ripened sufficiently. It is then cut in a clean, even fashion, the whey being allowed to escape. Some varieties of cheese require heating to assist in expulsion of the whey. This process gives the curd added firmness. The temperature must be raised very slowly. Curds for soft cheeses are not heated. They may in certain cases be allowed to soak in the whey before the liquid is drawn off. Heating reduces the cubes to approximately one-half their original size. Before the whey is drawn off, its acidity is tested, a further test being made when the liquid is level with the curd at the bottom of the vat. When the desired degree of acidity has been reached, the remainder of the whey is allowed to escape, the curd being drawn to one side of the vat to facilitate drainage operations. These are important. If whey is allowed to drain away before the required acidity has developed, the curd will not ripen properly. If left too long in the whey, the curd will become too acid. The resultant cheese will be dry and sour. Curd is considered ripe when it contains the correct percentage of acid and moisture.

Particular attention is paid by most cheese-makers to the solids content of the whey. The liquid should not contain more than 0·4 per cent. of fat and 0·8 per cent. of protein, this limit being maintained in well-managed factories. The solid mass of curd which remains after draining is cut into strips or cubes which are repeatedly turned to assist further escape of the whey. While continual turning of the curd is necessary in some types of cheese, the curd of other varieties is tied into cloths, which are opened at regular intervals to allow disintegration and to facilitate thorough drainage. *Hot-iron tests* are now applied, a small piece of curd denuded of moisture being placed on a heated iron and pulled away. If firm and threadlike strings are formed, the curd is ready for milling. When sufficiently dry and ripe, the curd is either broken by hand or passed through a curd mill, which cuts the material into pieces of uniform size. The latter method is to be preferred. The pieces are then spread over the bottom of the vat until a satisfactory hot-iron test has been obtained, salt being added in the ratio of 1½ to 2½ lb. for each 1,000 lb. of milk. The salt imparts flavour to the cheese and acts as a preservative. Only the highest-quality coarse-grained salt should be used. A soft curd is sometimes improved by increasing the quantity of salt added. Approximately one-third of the salt is sprinkled on the curd at a temperature of 90° F., the mass being stirred and spread out. This process is repeated until all the salt has been added.

When all the salt has been mixed with the curd, the whole is *pressed and ripened*. Some cheeses are not pressed, being moulded and allowed to drain naturally ; others are pressed and packed into moulds. Before *pressing* takes place, the curd is usually heated and placed in cheese hoops lined with prepared cloth. Pressure is then applied for varying periods, the time depending upon the type of cheese to be manufactured. After pressing, each cheese is bandaged. The bandaging and dressing process is important. The finishing touches applied by this means give the cheese an attractive and marketable appearance, while the bandages prevent its substance being damaged. Different methods of bandaging are used, according to choice. Care must be taken not to damage the edges of the cheese during this operation. Bandages should be made of the highest-quality cloth, circular caps for covering the ends of the cheese being particularly desirable. If pressing prior to ripening is required, the cheese is placed in the hoop after the bandages have been fixed. Pressure is applied, various types of hand or mechanical presses being used for this purpose. After adequate pressing, the cheeses are removed to the ripening room. Loss of weight occurs during processing and ripening. This varies according to the type of cheese.

The *ripening process*, which calls for expert attention, is controlled by (*a*) the balance of growth between the different organisms in the original milk, (*b*) the "starter" and the rennet, (*c*) the enzymes in the rennet, (*d*) the oxygen present, (*e*) the physical behaviour of the curd, (*f*) the development of acidity, (*g*) the presence of moisture, (*h*) the temperature and humidity of the cheese store, and (*i*) several factors still undetermined. The ripening process allows the characteristic flavour of a particular type of cheese to develop. It is actually a process of decomposition, which renders the cheese liable to attacks by moulds and, in some cases, by parasites. The control of temperature and humidity in the ripening room is of vital importance. Low temperatures, between 40° F. and 65° F., have been found more advantageous than high temperatures, the desired temperature being fixed according to the type of cheese to be ripened. Low temperatures prolong the ripening period, while a greater yield per gallon of milk will result. Ripening usually takes place in a humid atmosphere, the humidity being maintained by sprinkling the floor with water.

Physical and chemical alterations take place when cheese is ripened, the quantity of soluble nitrogen being increased, rendering the product more digestible and allowing the characteristic flavour to develop. The chemical changes result from the growth of organisms together with the action of the enzymes present in the rennet. The opinion was once held that proteolytic bacteria were vital to the satisfactory ripening of cheese. While these bacteria are numerous and active in certain soft cheeses, they are unimportant as regards the hard-pressed varieties. Acid-forming organisms are indispensable to the process of ripening. Cheeses manufactured from fresh milk, which contains few lactic-acid organisms, will not ripen. Acid-forming bacteria grow rapidly at all stages of the cheese-making process. Hard-pressed cheeses chiefly ripen following the action of ferments which result from the disintegration of the lactic-acid organisms present in the milk and rennet, the majority of these organisms being destroyed when the lactose content of cheese is exhausted. When bacteria disintegrate, they free endo-enzymes which act upon the protein. The ferments contained in the rennet are exceptionally active in bringing about chemical changes in cheese, this being evidenced by an increase in the percentage of soluble nitrogen present. Rennet extract contains the ferment pepsin, which finds the acidity furnished by the lactic-acid organisms ideal for its activities. By its influence paracasein is partially digested into albumoses and peptones. Rennet also possesses proteolytic properties. To ensure satisfactory ripening, the acidity produced by the lactic-acid organisms and the ferments of rennet must both be present.

The *flavours* which develop as cheese ripens are due to a variety of factors. Variations in the palatability of different species of cheese are due to products of the enzymes present, to lacto-bacilli, to protein degradation and to salts in the substance. The flavours are controlled by methods of manufacture, the texture of the cheese and by the conditions under which ripening takes place. Other important factors are the use of a virile "starter," the quality of the original milk and the absence of contamination in the rennet. Protein is an additional, if subsidiary, source of flavours. When cheese is ripening, the fat, lactose and protein decompose. In hard cheeses fat hydrolysis takes place slowly, proceeding more rapidly in the softer varieties. When ripened for lengthy periods, the fat hydrolysis induced by bacterial action results in the formation of small quantities of butyric, caproic and capric acids. All these have characteristic tastes and add to the aroma and flavour of the final product. During the ripening process, cheeses are turned at regular intervals. As milder-flavoured cheeses are now popular, the duration of the ripening process has tended to decrease.

Cream Cheese

Cream should be the main constituent of cream cheese, which was extensively manufactured in this country when conditions were normal. Many types exist, although some of the so-called cream cheeses contain very little cream, falling more correctly into the category of soft cheeses. The two varieties which may correctly be designated cream cheeses are *Selected*, containing 55 per cent. of butter-fat, and *Extra-selected*, which has a butter-fat content of 70 per cent. Cream intended for cheese-making should be fresh and sweet. The methods of manufacture in the case of both varieties are similar except that, whereas the double-cream variety sours naturally, rennet is used to coagulate the single-cream variety. When the *selected* cream variety is manufactured, the cream (12 to 20 per cent. fat) is mixed with an equal quantity of milk. The mixture is heated to between 60° F. and 65° F. Rennet is added together with a small quantity of " starter," being thoroughly stirred into the mixture, which is allowed to stand for three hours. When coagulation is complete, the curd is ladled into cloths. These are tied and hung in a dry airy place, being untied several times daily, scraped and the curd thoroughly mixed. The cloths should be changed daily. Drainage of the curd is completed within approximately forty-eight hours. With a view to accelerating the process, the curd may be placed between boards, a weight of 5 lb. being applied. Rapid draining enables the curd to be moulded within twenty-four hours. The cream should possess a thick pasty consistency when ready for moulding. When removed from the cloths, it should be thoroughly mixed with a small quantity of salt. The cream is then filled into moulds of various shapes and should be ready for use within three to four days. This type of cheese should be stored in a cool place and consumed quickly, as it loses flavour and appearance within ten days.

When *extra-selected* cream cheese is made, thick cream (40 to 50 per cent. fat) is pasteurised and cooled to 65° F. The cream is allowed to stand at this temperature for twelve hours, when it is placed in cloths and hung to drain in a cool place. The cloths are opened every four hours. The cream is scraped down to allow the hardened cream to make way for the still liquid substance in the interior. When firm, salt is added. The whole is then moulded, light pressure being occasionally applied. The cream should be soured if the cheeses are to be kept for any length of time. This type of cheese is usually sold fresh, in which state it is very perishable. A satisfactory cream cheese should be sweet to the palate, carefully prepared and ripened at low temperature. Such cheeses taint readily. All cloths and utensils used during processing should therefore be kept in a thoroughly clean condition. Cream cheese which is to be ripened should never be allowed to ripen naturally. If this is done, undesirable taints may develop. These will result in a greasy cheese which rapidly becomes rancid. Glascine-lined aluminium foil and tinfoil represent the best wrapping materials. Muslin wrappers will reduce the keeping quality of the cheese.

Processed Cheese

The production of processed cheese is continually expanding. The two main types are melted Cheddar varieties, produced in this country, and a

Gruyere type, manufactured in Switzerland. Other subsidiary types are also available. Approximately 40 per cent. of the cheese sold in the United States of America belongs to the processed variety, while this type of cheese has proved invaluable for use in tropical climates. Processed cheese is usually packed in small portions wrapped in tinfoil, although it is also marketed in blocks several pounds in weight. It possesses many advantages. It is possible to make use of cheese of varying textures and ages which, by judicious blending, can be manufactured into processed cheese. If suitably packed, such cheese will keep almost indefinitely and retain its quality. It should also be noted that processed cheese of high quality can be economically manufactured with simple apparatus provided care is exercised in the selection of the raw cheese and in the choice of emulsifying agents. The packages are attractive, a psychological factor which helps to increase sales. The cheese is soft, has no rind and is packed in portions of reasonable size. It does not become dry, waste being thus eliminated.

A number of cheeses of varying ages, textures, acidities and flavours are usually selected. A distinct flavour and uniform quality can be more readily obtained by this method. Usually, not less than six cheeses are selected for blending. The rinds are carefully removed. The substance is cut into slices or shredded, the portions being fed into a blending apparatus which further reduces the size of the pieces. Emulsifying agents such as sodium citrate or disodium phosphate (1 to 3 per cent.) are normally added to certain types of cheeses. The addition of a small quantity of water may also be required. Excessive quantities of water should not be used. The moisture content of the final product should not be more than 2 per cent. above that normally present in the type of cheese processed.

The ingredients are placed in a steam-jacketed vat together with lactic-acid solution, annatto often being added to obtain a uniform colour in the final product. Sufficient water is required to make good evaporative losses. Agitation is provided and the temperature of the blended cheese raised to between 140° F. and 150° F. Continued agitation, together with the application of heat, reduces the mixture to the consistency of thick cream. The addition of a small quantity of sodium citrate prevents any tendency on the part of the fat to separate and rise to the surface during cooking. The cooked cheese is smooth with a toffee-like consistency. It is either packed in moulds or boxes or is cut into various shapes and automatically wrapped. All metal surfaces coming into contact with the cheese should be constructed of stainless steel to prevent contamination and to permit of easy cleansing. After packing, the cheese is again cooled and is then ready for distribution. If the cheese is intended for export, a temperature of 170° F. for thirty minutes is used in processing, after which the liquid cheese is poured into cans which are afterwards sealed and sterilised at 230° F. for thirty minutes. Gruyere cheese is usually processed at 170° F. for thirty minutes.

Processed cheese is wrapped in tinfoil. As the foil is normally composed of a mixture of tin and antimony the risk of metallic contamination exists. Many of the foils now used for wrapping purposes are given a coating of shellac to protect the cheese from the action of the tin. The same result could be obtained by the use of some form of tissue paper in which the portions could be wrapped prior to attachment of the tinfoil wrapper. Soft cheeses wrapped without protection have been found to be blackened and mouldy and have been seized and destroyed as unfit for human consumption. Up to 14 grains of tin per pound have been found in soft processed cheeses on occasion. The quantity of tin present should never exceed 2 grains per pound. A smaller tin content is most desirable.

Dehydrated Cheese

Experiments have been carried out in the United States of America with a view to reducing the moisture content of cheese. A method has been devised whereby the moisture content has been reduced to 2·5 per cent. of the whole. If this process can be carried out on a commercial scale a weight saving of 35 per cent. would be effected. The final product takes the form of flakes which can be compressed into blocks. The idea behind the experiments has been to save shipping space and to improve transportation.

Canned Cheese

A method of canning cheese has recently been developed. This affords an excellent method of packing, reduces losses due to shrinkage and cuts labour costs. The cheese is placed in the can straight from the press and ripens in its own gas. Tests carried out with Cheddar cheese have given satisfactory results, and it would appear that other types might be canned in a similar manner. The can employed is fitted with a minute valve which relieves internal pressure without admitting air. Any accumulation of gas is allowed to escape. The valve remains closed if there is no pressure within the can. Oxidation cannot occur, while the growth of mould spores is prevented. Evaporation and shrinkage are eliminated, a fine rindless cheese being made available. Before canning, the cheese is wrapped in suitable transparent paper, the cans being properly sealed. Cans capable of holding up to 70 lb. of cheese are available. These are well lacquered. A cheese of uniformly high standard can be obtained, since by regulating the storage temperature the quality and flavour can be controlled within close limits. There is no waste, while cheese packed in this manner may be kept for long periods in perfect condition. Various types of cheeses have been canned in America, such cheeses being cured before they are packed. Packing takes place under vacuum in the presence of a small quantity of magnesium or calcium dioxide.

Cheese Spreads

A continued and increasing demand for cheese spreads, which will readily spread on bread, has been observed. These substances contain varying amounts of cheese, added to which are spices, fruits or vegetables together with other substances, such as milk or cream, condensed whey, whey powder or skimmed milk powder. Before they spread easily the moisture and fat content must be sufficiently high. The ingredients are heated to temperatures between 160° F. and 180° F. They are then treated with an emulsifier such as sodium citrate, after which the hot mixture is run into containers lined with tinfoil or into glass jars. The recommended standards of quality for cheese spreads state that the substance should have a minimum content of 45 per cent. butter-fat in the dry matter and a maximum moisture content of 48 per cent. Some inferior types of cheese spread produced prior to the war possessed a moisture content as high as 62 per cent. They should not be prepared by the simple emulsification of cheese and water.

Premises and Personnel

Premises used for cheese-making should be carefully planned and constructed. Their *aspect* is important, a northern light being desirable. If direct sunlight is able to obtain entrance to the rooms, the necessary control of temperature will be difficult. The building should be situated as far as possible from any likely source of contamination. The *roof* should be constructed of tiles in preference to slates, which are more subject to changes in temperature. When procurable, thatched roofing is satisfactory. *External lime-washing* of tiled roofs will assist in maintaining stable temperature within the building. Ample *natural and artificial lighting* together with *adequate ventilation* are essential. As a means of improving ventilation, all *windows* should preferably be fitted with fine wire gauze screens, to allow free circulation of air without admitting dust and insects. As internal temperatures play an important part in processing, *air conditioning* of premises is an added advantage. The *floor* should be constructed of hard impervious material. It should slope to surface gutters or channels which should discharge externally. Concrete or quarry tiles can be used for flooring purposes, the latter being impervious to moisture and cleanly in appearance. The internal surfaces of the *walls* should be smooth, cement rendering to a height of 5 feet being recommended. Glazed bricks and tiles, while costly, impart a more desirable finish. *Ceilings* should invariably be plastered. An adequate supply of *hot and cold water* is essential. A *boiler* of sufficient size to provide water for steam raising and water heating should be fitted in a separate boiler house. Some form of *heating* is necessary where cheese is manufactured throughout the year, in order to maintain an even temperature. The *sizes* of the various rooms will depend upon the quantities and varieties of cheese to be manufactured. Sufficient space should be allowed for pasteurisers, coolers and storage vats in the *milk treatment room.* The *cheese-making room* should be large enough to accommodate all the cheese vats and other equipment. A separate *pressing room* should be provided. The *ripening room* should be well ventilated and should possess adequately-controlled heating arrangements. A separate room for storage of " starter " should be considered essential. *Thermometers* should be fitted in all rooms. Hand-washing facilities should be installed adjacent to all treatment rooms, with an adequate supply of hot and cold water, soap and towels. While good-quality cheese may occasionally be manufactured with makeshift apparatus, modern *utensils* of satisfactory design must be used if a product of uniform quality is to result. Such utensils facilitate manufacture and simplify cleansing and sterilisation.

The *personnel* employed in manufacture should have sufficient skill to carry out their various duties without constant supervision. The control of acidity, moisture and temperature is important in the cheese-making process. Employees should therefore be intelligent and capable of acting on their own initiative. All workers should be clean in their habits and exhibit a satisfactory standard of health. Clean, healthy workers are just as important in the manufacture of cheese as in the production of any other foodstuff. Employees should be medically examined on commencing duty and should undergo periodical medical examinations.

The *cleansing and sterilisation of plant and utensils* is a matter of the very greatest importance. After cleansing, the utensils should be stored in a suitable clean place. Ample supplies of hot and cold water together with steam should be available. While chlorine solutions can also be used for sterilisation purposes, it must again be emphasised that there is at present no adequate substitute for steam. When it is remembered that cheese-making depends upon the growth of desirable bacteria and moulds, and that the development of undesirable types may cause incalculable harm, the need for constant vigilance in the matter of cleansing and sterilisation of the equipment will be appreciated.

Abnormalities in Cheese

Abnormalities are due mainly to the use of unsatisfactory raw milk, to faulty manufacturing methods and to bacterial action, each of these causes being closely related. If the milk and cheese are correctly treated, the development of harmful organisms may be avoided ; inefficient methods will result in bacterial growth even if high-quality milk is used. Milk containing colostrum curdles badly, while the curd obtained from such milk does not dry readily, the resultant cheese being spongy. *Sponginess* may also be due to the presence of gas-producing organisms in the milk or to an excess of lactose in the curd. The presence of gas-producing organisms is mainly due to gastric affections of the milking herd and to dirty methods of production. Carbon dioxide and hydrogen are most often formed, the former being most objectionable. The moisture present in cheese absorbs large quantities of carbon dioxide before any sponginess becomes apparent. Hydrogen is not so harmful. Butyric-acid organisms may cause the cheese to become spongy within a few days. Colon organisms produce hydrogen and acid due to fermentation of the milk sugar ; fermenting yeasts exert the same effect. If the curd is too acid or too dry through over-scalding, it becomes crisp and is easily cracked or broken, particularly if excess gas has been produced. Over-drying or the addition of excessive salt will produce a hard curd which is easily cracked. The rind also cracks if a large quantity of whey collects underneath. The hurried application of excessive pressure will crack the rind, the outer layer of cheese being compacted before the whey has had time to escape. Slimy whey also causes this defect. If cheeses are too damp but not over-acid they may become liquefied, particularly if large numbers of *Streptococcus liquefaciens* are present.

Colour defects may occur in cheese during the ripening period. On being cut cheese occasionally exhibits light patches within its substance, due to the presence of iron and copper salts which can gain entrance from water, from the direct use of steam for heating the milk or from a copper-lined cheese vat. If this defect is due to the presence of ferrous salts, exposure of the affected surface to the air will remove the discoloration. Colonies of chromogenic organisms sometimes develop in cheese, forming minute coloured spots throughout the substance. Blue spots in Edam cheese are caused by the presence of *B. cyaneofuscus* ; red or brown spots in Swiss cheese are due to chromogenic proprionic-acid bacteria. Blue mould is produced by *Aspergillus glaucus.* On occasion Cheddar cheese suffers from the presence of rust or red spots caused by the pigment-producing organism *Lactobacillus rudensis.* A similar type of discoloration is sometimes found in hard-pressed cheeses following the activities of coliform organisms or moulds of the genus *Oidium.* Red mould is produced by *Sporendonema caseii*, while Roquefort and similar cheeses occasionally exhibit a yellow discoloration presumed to be due to the activities of *Oidium lactis* or to micrococci. Chromogenic organisms such as *Micrococcus flavius*, *B. caseum fusci* or *B. firmitatis* are also responsible for a red coloration immediately underlying the rind. The presence of *Rhodococcus roseus* produces a red discoloration ; yellow and brown colours are produced by *Micrococcus flavius*, an organism commonly present in the atmosphere. The moulds *Penicillium caseii*, *Cladosporium herbarum*, *Monilia negra* and *Oidium aurantiacum* sometimes penetrate the rind, rendering the surface uneven and producing surface discolorations. Chalky whiteness in cheese is due to the mould *Oospora caseovorus*.

Defects in taste and smell are often present in cheese. Many of these are due to the feeding-stuffs supplied to cattle. These originally affect the milk and disappear in time. *Bitter or tallowy tastes* are chiefly due to the by-products of bacterial activity introduced as the result of careless handling or faults in manufacture. The organisms responsible for sponginess can also cause *bitterness*, which may further occur when fresh cheeses are stored in an atmosphere which is too cold or too damp. Many of the chromogenic organisms produce bitter tastes. *Streptococcus liquefaciens* and *Torula amara* are examples, although these organisms may disappear as ripening advances. Lactic-acid bacilli of various types can also cause bitterness. A tallowy flavour is sometimes noticeable in rich cheeses and is produced by the organisms which cause this flavour to develop in milk and butter. Undue exposure of cheese to sunlight may oxidise the fat and produce a tallowy taste. The presence of carbonic acid or copper salts may be a contributory cause. A *cabbage flavour* is produced in some French soft cheeses by the organism *Penicillium trevicaule*.

Manufacturing defects are common. Cheddar cheeses are sometimes *over-cooked or over-drained*, resulting in a dead flavour and dry, fatless texture. Such cheeses may also be *sweet, tough, over-acid* or *over-salted*, due to faulty methods of manufacture. Gorgonzola or Roquefort cheeses are sometimes discoloured owing to bacterial contamination during packing operations. The presence of liquefying organisms in Gorgonzola cheese causes bitterness ; ripening at too low temperatures will also produce this defect. Over-acidity is common. All manufacturing defects may be avoided if careful methods and strict cleanliness are observed and continuously maintained. As with other manufacturing processes, strict scientific control is essential throughout the process. *Cheese mites* or *cheese flies* may become a serious nuisance to cheese-makers. These insects are harmful to cheese, reproducing quickly, while eating into the substance at a very rapid rate. They may be responsible for spreading typhoid infections. To keep these insects in check the interior of the ripening room and its fittings should be thoroughly disinfected at frequent intervals, formaldehyde (2 per cent.) or ammonium bifluoride (2 per cent.) being used for the woodwork. Limewash to which 2 per cent. copper sulphate has been added should be used for the walls. Nothing short of the strictest cleanliness will prevent the development of undesirable organisms or parasites.

Composition

In view of the number of varieties produced, the composition of cheese may vary considerably. No standard has been fixed in this country, except for cream cheeses. In certain of the Dominions and in many foreign countries standards of composition are in force. Cheese contains milk-fat, casein, mineral salts and moisture, the percentages varying according to the type of cheese involved. The fat content may be as low as 18 per cent. of the whole, as in the Neufchatel variety, rising to 57 per cent. in the case of cream cheese. The casein content varies between 9 and 30 per cent., the ash or mineral content varying from 0·7 to 7 per cent. The absence of a compulsory standard of composition in this country enables cheese which contains little fat and which has been manufactured either from whole or skimmed milk to be sold without appropriate notification to the purchaser. This should not be permitted.

Cheese should not contain fat other than that derived from milk. Certain "*margarine cheeses*" have been placed on the market consisting mainly of an emulsification of skimmed milk together with various animal and vegetable fats. It is an offence under the Food and Drugs Act, 1938, to import or sell such cheeses without the prescribed labelling. In some countries the external surfaces of spurious cheeses of this nature must be dyed a distinctive colour.

Nutritive Value

Milk, which is the parent of cheese, contains fats, salts, protein and lactose together with a supply of each of the known vitamins, being particularly rich in vitamins A and G. In the case of cheese, the child is much more nutritious than the parent, containing as it does most of the milk solids with the exception of lactose, the bulk of which passes off in the whey. Cheese is milk in concentrated form. This fact will be readily appreciated when it is remembered that 1 gallon (10 lb.) of milk is required to produce 1 lb. of cheese. Cheese is especially rich in fat and protein and, if kept or ripened for a period, is very easily digested. Because of this, cheese should be three months old before it is consumed. Cheese is an extremely economical food, more than 90 per cent. of the assimilated material being changed into body tissue or energy. The digestibility of cheese has been demonstrated in a practical manner by a number of feeding experiments. Cheese should not be eaten on an empty stomach, between meals or in large quantities at the end of a meal. It has been stated that 1 lb. of cheese is equivalent in food value to 2½ lb. of meat and to approximately 2 lb. of fowl or pork, while its protein value, weight for weight, is twice that of the protein found in eggs. Cheese is adequate for nutritive requirements, containing as it does all the essential amino-acids. There is little waste with cheese, since it contains no bone and only half the moisture content of meat or eggs. Its comparatively reasonable price enables it to come within the reach of all classes of consumers.

Cheese can be utilised in numerous ways. It is extremely palatable, its flavour making it valuable as an appetiser. It does not require refrigeration and may be used in its natural state irrespective of weather conditions. Owing to the fact that there is nothing to distinguish skimmed-milk cheeses from the whole-milk varieties when exhibited for sale, a fat standard should be fixed for each grade of cheese, which should be properly labelled. It must be remembered, however, that the solids-other-than-fat possess high nutritive qualities.

Bacteria and Moulds in Cheese

Most of the organisms present in cheese belong to the *non-pathogenic types*. Such organisms are concerned in the ripening of cheese, the lactic-acid variety predominating. Lactic-acid organisms are particularly important. They produce acidity during ripening of the milk, activating the pepsin of the rennet and favouring coagulation. This co-operation of lactic-acid organisms and pepsin assists digestion of the protein. The acids formed check the growth of putrefactive bacteria which, if allowed to develop, would decompose the casein and render the cheese non-edible. The putrefactive organisms are chiefly responsible for off-flavours which develop in cheese. The bacterial content of *hard cheeses*—lactic-acid, mould and fermentative types—is reasonably simple. Cheddar and similar varieties of cheese represent the lactic-acid class. The acid-producing organisms which they contain suppress the other organisms originally present by the development of acidity. The same varieties of lactic-acid organisms are found in Danish cheese ; Edam cheese is manufactured from milk ripened by lactic-acid " starter." Gouda cheese, which is made from fresh milk, contains few lactic-acid organisms and ripens with the assistance of *Tetracoccus liquefaciens.* This imparts the characteristic flavour. Mould cheeses are ripened initially by the lactic-acid types, although at the later stages moulds develop within the cheese. Moulds are sometimes inoculated in the substance of cheese. These varieties ripen quickly.

The type of mould most commonly met with is *Penicillium roqueforti*, the absence of oxygen preventing many other types from developing. *Penicillium roqueforti* attacks both the fat and protein in the cheese, hydrolysis of fat being responsible for the characteristic taste and odour of Roquefort and similar cheeses. Roquefort cheese exhibits a mottled appearance due to mould growth. The same mould is responsible for ripening Gorgonzola cheese after it has received a preliminary ripening by lactic-acid organisms. *Oidium lactis* and other *Penicillium* moulds produce the bluish-green veins so characteristic of mould cheeses. *Penicillium glaucum* ripens Stilton cheeses. *Fermented cheeses*, mainly of the Swiss variety, are ripened in a different manner. As fresh milk is used, there is very little lactic acid in the curd before coagulation, while the small quantity of salt employed favours bacterial growth. The proteolytic changes which occur are caused by lactic-acid organisms, although the flavour is due to organisms of the *B. bulgaricus* group. The characteristic " eyes " are formed following fermentation by the by-products given off by the lactic-acid organisms and by proprionic-acid bacteria. Organisms of *B. bulgaricus* group are plentiful in rennet, the most important member of the species being *Thermobacterium helveticum.*

Soft cheeses may be of the " smeared " or " mouldy " variety. With the " smeared " type the surface growth of mould is suppressed by wiping the external surfaces with a damp cloth. Limburg cheese is representative of this group. Internal ripening is produced by rennet and lactic-acid bacteria, external ripening being due to the growth of moulds on the exterior surfaces. These give the cheese its familiar pungent odour. Surface moulds are formed by a peptonising tetracoccus and by *B. casei Limburgensis*, this latter organism oxidising the lactic acid. *B. casei Limburgensis* does not attack the protein, living upon the amino-acids produced by the peptonising tetracoccus. Decomposition is carried a stage further than is the case in other types of cheeses. Ammonia is produced, spreading inwards, neutralising the lactic acid and converting the casein into soluble ammonium caseinate. This action permits other bacteria to develop and causes further decomposition. With " mouldy " cheeses surface growth of moulds is encouraged by keeping the external surface dry and by providing free access of air. Camembert cheese is representative of this type, in which the milk used in production is ripened by lactic-acid organisms. Because of the method of manufacture, large quantities of whey are retained in the curd. The activity of the lactic-acid organisms causes the acidity to be high. This protects the interior substance from the activities of proteolytic organisms. Many types of bacteria, yeasts and moulds settle upon the external surfaces of the cheese and grow inwards, neutralising the acidity and changing the texture. The *Oidium* types, principally *Oidium lactis*, are the first to appear. As the surface dries the mould *Penicillium camemberti* makes its appearance, this mould being particularly active in reducing acidity. These moulds also produce enzymes which digest the curd, inducing conditions favourable to the development of proteolytic organisms such as *B. casei Limburgensis*, which are already present. Because of the reduced acidity, putrefactive organisms may exhibit great activity and cause decomposition shortly after the cheese has ripened.

A considerable portion of all cheese is manufactured from raw milk and may therefore contain any of the *pathogenic organisms* present in the original liquid, particularly if the cheese is consumed in a fresh unripened state. The most important pathogenic organism found in cheese is *Mycobacterium tuberculosis*. This has been isolated from a considerable number of farmhouse cheeses. In cheeses of the Cheddar type, *Mycobacterium tuberculosis* may remain virulent up to seventy days. In the Swiss variety these organisms usually disappear within forty days of manufacture. The presence of *hæmolytic streptococci* and *Brucella abortus* must not be overlooked, as these organisms may be present in the original milk supply. *Brucella melitensis* may be present in unripened cheeses manufactured from goats' milk. Because of the unaccustomed environment, it is doubtful whether these organisms retain their virulence for any lengthy period. Apart from the pathogenic organisms found in milk from which cheese has been manufactured, infection by human pathogens may occur during or after production. *Salmonella typhosus* has been isolated, but does not survive in cheese for more than twenty-five days, probably disappearing much more quickly. *Corynebacterium diphtheriæ* does not survive in cheese for more than fourteen days, while *Vibrio choleræ* is reported to become extinct in two to three days. *Food-poisoning organisms* may also be present. The fact that pathogens may occur in cheese, particularly those produced from unpasteurised milk and the unripened varieties, provides a sound argument why milk intended for cheese manufacture should be pasteurised before any " starter " is added. In many American States regulations are in force which require that cheeses of the hard variety shall be manufactured from pasteurised milk, shall be pasteurised after production or shall be held for sixty days before sale if manufactured from raw milk. A sixty-day storage period will provide complete protection from a public health standpoint.

Epidemiology

The main disease outbreaks traced to infected cheese have been confined to cases of food poisoning, although epidemics of other diseases have been reported from America. Cheese is associated with a distinct type of poisoning of doubtful ætiology. Cheese poisoning was formerly attributed to the toxic substance *tyro-toxicon*. Research has since shown that this toxic agent is not responsible for poisoning caused by cheese. Several toxins are probably involved, some being products of members of the Gaertner group as yet unclassified. It may be, indeed, that the toxins are well-known members of this group which have been so altered by the enzymes or ferments present in the cheese as to be unrecognisable. The cheeses so affected rarely exhibit any physical abnormalities. In 1922, Canadian Cheddar cheese gave rise to cases of food poisoning. No causative organisms were isolated. In the same year there was an outbreak due to the consumption of Wensleydale cheese. Agglutination tests for the presence of the Salmonella group gave positive results. Tyro-toxicon was not found in any of the cheese. In 1923, at Harrogate, twelve persons were attacked by food poisoning, the severity of the symptoms corresponding to the quantity of cheese consumed. In the portion of the cheese examined no tyro-toxicon was found ; the sera of two patients agglutinated two separate Salmonella strains. During 1933 two outbreaks of food poisoning due to cheese were reported, thirty persons being affected. These outbreaks were ascribed to imported Cheddar cheese. Clinically the cases were of the toxin type ; bacteriological examination gave negative results. Cases of *staphylococcal poisoning* due to the consumption of cheese infected with *Staphylococcus albus* and *Staphylococcus aureus* have been reported from America, while cases of *botulism* due to cheese from which *Clostridium botulinum* (Type B) was isolated have also been reported. *Typhoid fever* epidemics have been reported from America following the consumption of infected cheese. One of these outbreaks, which occurred in 1923 and involved fifty-one cases with four deaths, was traced to cheese made at a farm on which a typhoid " carrier " was employed. The cheese was a month old when eaten. A similar outbreak occurred in Canada, 627 persons being affected, of whom fifty-seven died. The manufacturers of the infecting cheese used milk from farms on which there had been, and still were, cases of typhoid fever. The cheese was consumed in a partially-ripened state.

Control

As with all other foodstuffs, cheese production and distribution should be strictly controlled. Particular attention should be paid to the quality of the raw milk and its efficient pasteurisation, the methods of ripening employed and the standard of cleanliness observed, particularly during handling. The health of the personnel should not be overlooked. Laboratory control methods fall into two distinct sections. *Bacteriological* control is used to determine the presence of specific organisms, particularly pathogenic types, while mould and yeast counts can also be made. Although no official standard has been fixed, *chemical examinations* are employed in the estimation of (*a*) fat content, particularly foreign fats, (*b*) percentage of moisture, and (*c*) presence of colouring matters and preservatives. The phosphatase test is also used to gauge the efficiency of milk processing. Cheese should not contain fat other than that derived from milk. Cheeses may be contaminated externally with foreign substances such as lead chromate or copper sulphate, these materials being occasionally applied as a protection against attacks of mites and other insects. Ferrous sulphide has been found in Parmesan cheese, while a substance containing sulphate of zinc has been used on occasion to prevent cracking.

Whey

Whey, of which extensive quantities are produced annually, is the only by-product of cheese manufacture. Although a substantial portion of the output is utilised in various ways, it is estimated that millions of gallons are wasted each year, costly treatment plants being necessitated to prevent the contamination of streams adjoining creameries. It does not seem logical that half the original value of milk should be wasted in this way. The whey could either be returned to the farmer for pig feeding or could be evaporated or dried. It might also be made into whey cheese or whey butter, while the lactose could be extracted. Whey returned to the producer for animal feeding should either be pasteurised or sterilised before it leaves the factory.

Whey possesses a high moisture content, the fat, casein and ash content being negligible. The lactose content is virtually unimpaired. The liquid is usually greenish in colour, white-coloured whey denoting a curd which has been roughly handled during cutting operations. When discharged from the cheese vats or presses, whey should have the appearance of clear brine. It contains sixteen times as much lactose and twice as much albumin as butter. Because of its low fat content, whey does not sour readily. It is invaluable for animal feeding and has a definite food value with a high vitamin content, being particularly rich in calcium and vitamin G. Whey is often used for bread making, being employed in lieu of milk. After pasteurisation it should be cooled by means of water, as brine-cooled whey prevents the proper working of the yeast in the bread. In Germany whey has been condensed into a syrup for use in bakeries and for mixing with animal feeding stuffs.

CHAPTER XVI

MILK PRODUCTS

Cream

CREAM is one of the most important products of milk, partly because of the ready sale which it enjoys in its natural state and also because it is the prime constituent of butter and of certain varieties of cheese. Prior to the War, cream in one form or another had become virtually an article of everyday diet, particularly in the large towns, where various types of cream, known as "Coffee Cream" or "Fruit Cream," were sold in large and increasing quantities. These types of cream were sufficiently low in cost to place them within the reach of the majority of consumers. The distribution of cream had reached very considerable dimensions when war-time restrictions dictated total prohibition. Suggestions have recently been put forward for a resumption of the sale of cream, two grades, with 18 and 48 per cent. of butter-fat respectively, having been considered suitable. It is unlikely, however, that cream with the highest butter-fat content will be available for some time owing to the quantity of milk required for its separation.

Production of Cream

Butter-fat in milk is present in the form of small globules which vary in size according to the breed of animal producing the milk and the period of lactation. The butter-fat in milk, being the lightest portion of the liquid, rises to the surface when the product is allowed to stand. This feature has been employed in the *separation of cream*, since the fat may be skimmed or poured off, leaving behind the watery serum which contains the protein and mineral salts. Three methods of separating cream from milk are in use, two of which rely on *hand skimming*. These latter methods are still employed by some persons. Originally the warm milk was strained into shallow pans in which it was allowed to stand for twenty-four to thirty-six hours. The cream was then removed by means of a skimmer. Complete removal of the cream by this method is impossible, 0·5 to 1 per cent. of the butter-fat being retained in the skimmed milk. The cream produced depended upon the time during which the milk was allowed to stand, the temperature, the type of milk-fat and the depth of skimming. When this method was employed, the casein contained in the milk frequently curdled before the cream had finished rising, thus preventing complete removal. The "deep setting" system was devised to overcome these difficulties, the milk being placed in deep pans which could be cooled. Souring or curdling of the milk was thus prevented. The cream is either removed by means of a skimmer or the watery liquid is drawn from the base of the pan without disturbing the cream. If carefully carried out, not more than 0·2 per cent. of the cream remains behind. Hand-skimmed cream usually possesses a higher bacterial content than is found in cream which has been mechanically separated, the bacteria tending to rise with the cream.

Mechanical separation is now common practice, the separator being either hand or power driven. The first cream separator was invented by Neilsen in 1878. The original machines were of the hollow-bowl type, with siphons to carry away the cream and the separated milk. The size of the bowl was later reduced, discs being introduced to provide increased capacity and greater skimming efficiency. The mechanical separation of cream depends upon the difference between the specific gravity of the milk serum (1·036) and that of butter-fat (0·9). Fresh milk can be separated mechanically, there being no need to stand the milk for any period. A higher percentage of fat is removed by this method, while the operation can be regulated to produce different types of cream. As the cream is perfectly fresh, the bacterial content is low. Separators may be of the normal disc type. The discs may be replaced by curved plates, or the apparatus may be of the tubular bowl type, operating at high speeds. The degree of separation depends upon the speed at which the bowl operates, the uniformity of that speed, the temperature of the milk and the rate of inflow. The chemical and physical condition of the milk also exerts an influence. The power-driven type of separator is more economical than the hand-driven type, a better cream being obtained. Airtight separators are also employed. These prevent foaming and have a high skimming efficiency. Apparatus has been devised to provide *plastic cream* having a fat content in the region of 80 per cent. or above. The higher the speed at which the apparatus operates, the more completely is the cream separated.

Adjustments can be made which will produce creams with varying fat percentages. Ten gallons of milk will give 7 pints of cream with 50 per cent. butter-fat, 1 gallon of cream with a 35 to 38 per cent. fat content or 2 gallons of cream with 22 to 25 per cent. of fat. The ideal temperature at which separation should be carried out is 90° F., the milk being warmed quickly immediately prior to separation. Lower temperatures will give a richer cream, although more fat is lost in the skimmed milk. The inflow of milk to the separator is usually controlled by an adjustable float. Mechanical separators make use of centrifugal action, the liquid being spun on to a disc which impels the watery serum towards the periphery, the fat or lighter portion remaining nearest the centre. Separators should be installed in such a way that the supporting axle is vertical. The slightest deviation will produce an uneven drag on the bearings, resulting in excessive wear. Cleanliness is of the utmost importance. Separators should be dismantled immediately after use. The parts should be thoroughly scrubbed in hot water (180° F.) and sterilised with steam or hypochlorite solutions before re-assembly. If strict attention is paid to cleanliness, a raw cream possessing a low bacterial content can be produced provided the original milk is of high quality.

As cream may be a potent source of human infection, it should be *pasteurised* before being sold for consumption. Pasteurisation also improves its keeping qualities, as the addition of preservatives is forbidden. Both low- and high-temperature methods are employed, whilst vacuum pasteurisation can be used, the latter process removing off-flavours and feed taints. Pasteurisation affects the viscosity of the cream, although subsequent homogenisation will remedy this. After processing, the cream should be well cooled, the prevention of contamination during and after cooling being essential. Pasteurising apparatus and coolers should be dismantled immediately after use. They should be thoroughly cleansed and sterilised before being used again. The exercise of strict cleanliness is essential if an efficiently-pasteurised product is to result.

Cream is often *homogenised* to increase its viscosity. The higher the pressures employed, the greater is the viscosity increased. Increased viscosity enhances the flavour, appearance and palatability of cream, while serum separation is prevented. No change takes place in the chemical composition, nor is the bacterial content reduced by homogenisation. *Viscosity* depends upon a number of factors, one such factor being the tendency of the fat globules to coalesce. This in turn depends upon temperature, the size of the globules and the effect of agitation. Maximum agglutination occurs at 45° F., agglutination being reduced as the temperature rises. Agitation at low temperatures assists agglutination. If cream is agitated at high temperatures any clumps already formed will disperse. The butter-fat content of the cream naturally affects the viscosity, while pasteurisation produces a decrease.

Ageing of cream at low temperatures increases viscosity, even before sufficient acidity has developed to coagulate the casein. The most rapid increase takes place in the first twenty-four hours of the ageing process, the maximum being approached after a period of forty-eight hours. High pressures during homogenisation increase viscosity, although cream treated in this way would tend to "feather" in coffee. Slow cooling of the cream will also increase its viscosity. High-fat cream is not usually homogenised, although process is essential if the product is to be canned. Commercially, cream is normally homogenised, after pasteurisation and before cooling, at pressures in the region of 1,700 lb. per square inch and at a temperature of 130° F. This treatment is sometimes carried out in two stages, a secondary treatment being given at a pressure of 800 to 1,000 lb. per square inch. This prevents the clumping of the fat globules. The homogeniser must be efficiently cleansed and sterilised after use.

High-quality cream can be kept in *storage* at 0° F. for periods up to six months without impairing flavour or quality. It must, however, be perfectly fresh when stored, while clean containers must be used. Cream should not come into contact with any copper or iron surfaces during storage, otherwise a metallic flavour will be produced. This flavour becomes more pronounced as the substance ages. The methods previously employed in the *sale of cream* left much to be desired. The usual practice was to deliver the product in waxed cardboard cartons. If sold from a shop, the cartons were filled on demand from a basin of cream, often uncovered, which stood on the counter. This practice resulted in serious contamination of the product, particularly in the case of pasteurised cream, which is particularly liable to recontamination if not carefully handled. When conditions return to normal, these points should receive careful attention. The sale of unpasteurised cream should be prohibited, while any sales should only be permitted in containers sealed at the dairy. The waxed cartons do not exert any effect upon the liquid, although it is important to ensure that no contamination of these containers takes place during storage or before filling. Cartons should not be exposed to dust and dirt ; the number of cartons unwrapped should never exceed the total required for immediate use. It must again be emphasised that, so far as this country is concerned, the remarks set out above apply to the future when cream is once more made available.

Clotted Cream

The manufacture of clotted cream has been centred for many years in the south-western counties of Somerset, Devon and Cornwall. When the addition of preservatives to cream was forbidden, production tended to fall, although improved methods of manufacture have overcome many of the difficulties encountered. Large-scale manufacture had begun prior to the War, further development of which was interrupted by hostilities, although manufacture has again commenced following the withdrawal of restrictions, but on a reduced scale. Clotted cream was long considered a luxury but has been widely recommended by the medical profession as an excellent fatty food, particularly useful in invalid diets. It is very rich, containing from 60 to 70 per cent fat, present in a finely emulsified state. This aids digestion. Milk containing a high fat percentage should be used in the preparation of clotted cream. When such milk is used, the process must be speeded up, scalding taking place at slightly higher temperatures. Excessive temperatures must, however, be avoided, otherwise the product will take on a peculiar boiled taste and be rough in appearance, with a white-flaked surface. If the milk-fat is present in large globules, the period required for setting should be reduced. Milk of this type must be heated to a higher temperature and must be retained for a longer period at that temperature.

Several systems of preparation are employed, resulting in considerable variations in texture, flavour and appearance of the finished article. The flavour and physical consistency depend upon the acidity of the original milk, the temperature of scalding and the time allowed for this purpose. The *earthenware bowl method* of preparation was originally used. In this method the bowl stands over a water jacket to which gentle heat is applied. This prevents boiling point being reached and ensures that the cream layer is not disturbed. The whole is then allowed to cool without disturbance, the milk remaining in the bowl over night. The cream layer is removed on the following morning by means of a skimmer. When the *shallow pan system* is used, the warm milk from the cow is strained into setting pans. These are allowed to stand so that the cream may rise. The milk is then heated on a hot-water stove to a temperature between 170° F. and 190° F. for some twenty minutes, and is then allowed to cool. When scalding is complete, the cream will separate from the sides of the pan and exhibit a crinkled appearance. It is then removed by means of a perforated skimmer. *Scalding over separated milk* has now become a popular method, entailing less labour than the methods already described. The milk is separated, a cream containing 60 per cent. of fat being obtained. One quart of separated milk is placed in each setting pan. Two quarts of cream are floated over the liquid. Scalding for fifty minutes at 195° F. follows, after which the pan is removed and cooled. The cream is ready for use after eight to twelve hours. The resultant product possesses a pleasing flavour and has excellent keeping qualities.

When the *direct scalding method* is used, cream is poured into shallow pans and scalded. A small quantity of sugar is often added to improve keeping quality and flavour. The cream is stirred thoroughly during the scalding period of fifteen minutes to aerate the product and to improve flavour. *Cooling* is important. In the past much clotted cream has become sour or bitter owing to the presence of lipolytic and proteolytic organisms. Bacterial multiplication during the slow cooling period which follows scalding operations presents a problem. Accelerated cooling arrangements in a sterile atmosphere are essential, while the characteristic flavour and texture must be preserved. All utensils, e.g. separators, pans and skimmers, should be efficiently cleansed and sterilised and should always be stored in a clean place The process of clotting may not destroy those pathogenic organisms which may be present in the original milk or cream. An appreciable degree of contamination during packing is much more likely to occur with clotted cream than is the case with liquid cream, extreme care being therefore indicated.

Canned Cream

Considerable quantities of canned cream were sold in this country prior to the War, the greater proportion being imported from abroad. There is little doubt that sales will be renewed when circumstances permit. During production milk is separated to give a 40 to 50 per cent. fat content. The resultant cream is diluted with separated milk until the fat percentage is approximately 23 per cent. Acidity is also adjusted. Sodium citrate in the ratio of 1 ounce to 10 gallons of the mixture is added as a stabilising agent to prevent undesirable changes in consistency. Sodium phosphate or bicarbonate can also be used as stabilisers. These substances yield a thicker cream. The mixture is then heated to 150° F., homogenised at 2,400 lb. pressure and filled into cans. The cans are exhausted, sealed and sterilised at 236° F. for twenty minutes in a pressure retort, care being taken to ensure uniform heating of the cans and their contents. Canned cream exhibits a flavour peculiarly its own, due to processing. Viscosity is high, although sterilisation spoils the whipping properties. *Bottled cream* is treated in a similar manner, except that a pressure of 1,600 lb. per square inch is used for homogenisation, while sterilising temperatures are in the region of 225° F. to 230° F. The fat content is low, amounting to approximately 23 per cent. The label on which this percentage is printed is misleading, the article being almost universally described as " rich cream." The solids-not-fat content varies between 6·5 and 9·5 per cent.

Neutralising agents are sometimes added to canned cream to vary the consistency. The texture should be smooth. *Graininess* and *lumpiness*, which are occasionally found, may be removed by the careful use of neutralising agents. *Separation* represents another defect, a thin fluid serum being exuded. This is usually due to prolonged storage and can normally be removed by shaking. *Bitterness* and *thinning* are also found in canned cream, one defect generally accompanying the other. Both defects are due to a heat-resistant strain of *B. subtilis*, which breaks down the milk proteins. *Coagulation* sometimes occurs due to acidity developing through bacterial activity. This defect is usually accompanied by the production of gas. The responsible organisms gain entrance from defects in the can or through faulty sealing. *Discoloration* may occur owing to breakdown of the protein content. The can may at times exhibit a corroded appearance due to pitting, while loose black particles may be distributed throughout the cream.

Sterilised Cream

A method of sterilising cream without the development of those chemical changes which cause caramelisation and instability was patented in America in 1939. The sterilised product exhibits extremely stable properties, the cooked flavour or burnt taste usually associated with excessive heating being almost completely absent. Fresh cream with an acidity less than 0·15 per cent. is piped to a storage tank, 0·1 to 0·25 per cent. of sodium alginate being added. This acts as a stabiliser and prevents separation of the milk solids during extended storage. After preheating under pressure, the cream is sterilised at 260° F. to 280° F. in a continuous flow by the direct application of high-pressure steam, four minutes being required for this process. It is then homogenised in two stages, pressures of approximately 2,000 and 500 lb. per square inch respectively being used, the homogenisation temperature being just under 150° F. Care is taken to ensure that the cream does not become too viscous during this treatment, which is followed by cooling and bottling. Bottle-filling and capping are carried out in a separate room in which ultra-violet-ray lamps emit sterilising radiations. These destroy any bacteria or moulds which may be present. The operatives wear sterilised overalls, gloves and masks and are subjected to regular medical inspections, particularly as regards the presence of respiratory diseases. Both bottles and caps are sterilised at 275° F., the bottle conveyor being protected by a bank of bactericidal lamps. The air of the room used for filling and capping is washed and filtered, dust being precipitated and the desired temperature and humidity maintained. Bactericidal lamps in the air ducts provide a further precaution against contamination. The filled bottles are removed to cold storage on an air-cooled conveyor. Bottles from each batch are tested for sterility and are submitted to a churning action to test the stability of the finished article.

Defects in Cream

In common with other foodstuffs, cream is subject to certain defects or faults due to unsatisfactory processing or handling. The purchaser expects a clean-flavoured product with good keeping qualities, natural colour and sufficient viscosity to make it appear reasonably rich. The cream should whip easily and should have suitable stability. *Poor keeping quality* is a common defect. If cream is to be stored in the home unrefrigerated, this defect becomes significant. The extended ageing of cream will injure its keeping quality, although this defect is mainly due to high bacterial content of the original milk and to the use of improperly cleansed and sterilised apparatus and containers. *Poor flavour* may be due to a variety of causes. Flavour depends upon the quality of the original milk supply, a clean, wholesome flavour being only possible when fresh milk of good quality is separated. Ageing for lengthy periods, carried out to increase the viscosity, should be avoided. Bitter or rancid flavours may develop, due to the presence of non-spore-forming organisms of soil and water origin, which cause spoilage at low temperatures. Mould growth will cause deterioration of flavour ; tallowy flavours are due to oxidation of the fat by exposure to strong sunlight or to contact with unsuitable metal surfaces during processing. The action of lipase may cause rancidity or bitterness. This enzyme may only be secreted in the milk of a few cows, but if mixed with the bulk supply the entire consignment will be tainted.

Cream-plug formation is caused by excessive agitation of the cream in partially-filled tanks or cans, or by the use of high-speed pumps. Cream should be cooled quickly, while excessive heating must always be avoided. *Poor colour* is a common defect. The colour intensity in partially-churned cream is not so great as in cream which is in natural emulsion. Homogenisation increases colour, as will the building up of the solids-not-fat content. This latter practice may affect the flavour. Too much handling, agitation, pumping and separation at high temperatures, together with the separation of warm milk and ultra-rapid cooling, are the commonest causes of *thin body*. Natural clumping of the fat globules should be encouraged by (*a*) proper handling of milk prior to separation, (*b*) gentle handling of the cream, and (*c*) slow cooling to less than 55° F. The factors responsible for *serum separation* are excessive pumping, which causes partial churning of the cream, high-temperature separation and low fat content. This defect, which is evidenced by rising of the fat and serum separation, does not occur if the viscosity is sufficient to retain the fat globules in position throughout the serum. It may be prevented by high pasteurisation temperatures, gentle agitation and low separation temperatures. The causative factors of "*oiling off*" are freezing of the cream during cooling, the separation of excessively hot or cold milk, the pasteurisation of very rich cream, and the employment of high temperatures. Undue agitation of warm cream prior to pasteurisation, high-speed pumping, slow cooling in the pasteuriser and the use of a heating medium at too high a temperature may also be responsible. Homogenisation at a pressure of 300 lb. per square inch will prevent this defect. *Feathery cream* is highly acid and contains calcium or magnesium salts in excess. Homogenisation at excessive pressures also produces this defect. Cream sometimes exhibits *poor whipping qualities*. This may be due to temperature and to the type of whipping apparatus employed. Excessive ageing, partial freezing and homogenisation are the main causes. Sugar, which is sometimes added to cream, should be mixed with the substance towards the end of the whipping process. If sugar is added too quickly the whipping quality of the cream will be affected.

Composition

Cream consists of the butter-fat globules present in the original milk, together with a certain quantity of milk protein which adheres to these particles after separation. This occurs most often in hand-skimmed cream. Because of the action of lactic acid, a slightly acid milk produces a thick cream. Fresh milk yields a thin cream owing to the fact that the protein is in finer suspension. If this type of cream is allowed to stand for some time, the lactic-acid content increases with a consequent thickening of the product. The composition of cream varies according to type. Clotted cream is richest in butter-fat, averaging 50 to 75 per cent., and contains least moisture. Normal thick cream has a butter-fat percentage of 48 while utility cream contains approximately 15 per cent. butter-fat and has a greater moisture content. Sterilised cream has a butter-fat content of approximately 23 per cent. The protein content of the various types of cream varies from 1·5 to 6 per cent., the lactose content from 1 to 4·5 per cent., being the highest in thin cream, and the ash content from 0·3 to 0·63 per cent. The quality of cream obtained from a given sample of milk depends upon the composition and quality of the original liquid. This, in turn, is governed by such factors as the breed and individuality of the cow, seasonal variations, the efficiency of the milker, the period of lactation and to a minor degree, the food consumed by the animals in the herd. The vitamin content of cream is similar to that of the original milk. Cream usually possesses a high cellular content, due to manipulation of the udder during the stripping process.

Nutritive Value

Cream has considerable food value and is particularly useful during sickness and convalescence, not only by virtue of the nourishment which it contains but also because of its palatability. Cream furnishes the body with heat and energy and contains most of the colouring matter present in milk. It represents milk in which the normal proportion of fat has been increased, mainly at the expense of the moisture removed during the separation process. The quantity of protein and lactose present in cream is approximately half that contained in average cows' milk. The fat percentage varies considerably.

Bacteria in Cream

The bacteria present in cream, particularly in unpasteurised cream, are similar to those found in the raw milk from which the cream has been obtained. Their numbers are likely to be much higher, as they tend to rise to the surface or cling to the butter-fat. *Pathogenic organisms* of both animal or human origin may be present ; the principal *non-pathogenic types* are lactic-acid-producing bacteria and organisms of the coliform group. The sources through which these organisms gain entrance to milk have already been considered in Chapter XI, pp. 141 to 144.

Epidemiology

Instances of animal disease transmitted by means of cream are rare, although the possibility must be borne in mind if the liquid has not been pasteurised before sale. Several outbreaks of disease have occurred due to contamination of cream from human sources. A *typhoid fever* outbreak occurred in Liverpool in 1896, in which twenty cases were notified. Infection of the cream cans at a house where a case of typhoid fever had occurred was the cause of the outbreak. An outbreak of *paratyphoid B fever* involving eighty-seven cases was reported from Leamington during 1924, and was traced to confectionery produced at an establishment where a " carrier " was working. Cream used for filling cream cakes was believed to be the medium of infection. In July and August, 1928, 400 cases of paratyphoid B fever were notified from several West London boroughs and from the Home Counties, cream from one wholesale dealer being implicated. The supply had been obtained from three sources, two of which were outside this country. The actual point of infection was never traced. The cream had received some form of heat treatment by the dealer. It is probable that this treatment was generally inefficient or that some portion of the cream had not been sufficiently heated.

Control

The control of cream supplies closely follows that of milk, being governed by similar regulations, the definition of " milk " in existing food legislation including cream. Both *bacteriological and chemical control* is operated along similar lines, with the inclusion of examinations for preservatives, colouring, thickening materials and gelatine or other stabilisers. The methods of control applicable to milk have already been outlined in Chapter XI, pp. 153 to 154. Cream should always be handled in suitable dairy premises which should conform to the various Acts and Regulations in force.

Artificial Cream

The advent of the ban on preservatives in cream produced a substantial increase in the quantity of artificial cream manufactured and sold. The ban on the production and sale of fresh cream in 1939 resulted in a still further increase. This has been especially noticeable among confectioners, many of whom use artificial cream as a filling for cakes and pastries, not only because of the absence of the natural variety but also because of losses which sometimes occur due to souring. Artificial cream is useful on board ship or where a variable market exists. Many descriptions have been applied to artificial cream. "Reconstituted cream" has been used but is inaccurate, as the article has never been cream. "Synthetic cream" is a still more unfortunate caption, having been used to denote an article derived from fats other than milk.

Artificial cream can be manufactured in the home from a variety of ingredients, such as unsalted butter, margarine, dried skimmed milk powder, stabiliser and water. A small hand-operated emulsifier is used for its production. When prepared commercially, the same ingredients may be used if and when available, although cornflour and dried egg may be substituted for the unobtainable dairy products. Bakers' cream filling is made from vegetable fat, such as margarine, sugar, marshmallow produced from sugar, gelatine and water, and flavouring materials. If dried egg is used, certain conditions relating to speedy mixing, heat treatment and cooling of the artificial cream must be observed. The ingredients are mixed, usually heated to boiling point and agitated at high speeds for several minutes. The mixture is then cooled and finally homogenised to secure a permanent and complete emulsion.

Several outbreaks of paratyphoid B fever occurred during the War which were stated to be due to the consumption of infected artificial cream. Cream-filled bakery foods are especially liable to salmonella and staphylococcal contamination and have been the cause of food-poisoning outbreaks. It appears that these organisms have a great liking for artificial cream so that a few organisms obtaining entrance to a batch of cream may increase to many millions within a few hours. Artificial or synthetic creams should be handled as little as possible to prevent bacterial infection. Manufacture and sale are subject to legislative control in the Food and Drugs (Milk, Dairies and Artificial Cream) Act, 1950. The premises are required to be registered and the article specially labelled. The operation of these controls is vested in the food and drugs authority for the area.

Fermented Milks

Fermentation is one of the oldest known methods of preserving or improving the nutritive qualities of milk. While the process is still carried on in this country, modern methods of food preparation have very largely removed the necessity for fermentation. On the other hand, a growing demand exists for fermented milks, which are largely of foreign origin, because of their alleged health-giving properties. To preserve milk by fermentation various types of fermenting organisms, mentioned below, are added, according to the type of fermentation required. These organisms produce substances which retard decomposition. In some countries the necessary organisms are found in the milk, but milk may be artificially inoculated if desired. The fact that milk could not be kept fresh was presumably the origin of the custom of drinking soured or fermented milks, since, once the liquid has clotted, the acidity prevents further decomposition. Various authorities have stated that the health of the population would be improved by the consumption of such milks, which are said to be capable of reinstating acid-forming organisms in the body, restraining putrefactive changes and preventing the absorption of toxins produced by protein digestion. Apart from the medicinal properties outlined above, fermented milks have a useful food value, although in some cases the fat may be partially or completely removed. They are also pleasant to the palate and refreshing. The lactose content is only slightly reduced, part being converted into acid, alcohol and gas. The casein is precipitated in an easily digestible state. Fermented milks are frequently prescribed in cases of gastric irritation, when it is difficult to select foods which will be retained.

Kefir

Kefir, one of the oldest varieties of fermented milk, contains a high percentage of alcohol and gas. This type of milk is produced by a ferment which has the appearance of yellow grains. The organisms present in kefir grains include *Streptococcus casei*, *Betabacterium caucasium*, which resembles *B. bulgaricus* in that it forms gas from lactose, fermenting organisms similar to *B. coli* and *B. cloacæ*, together with yeasts such as *Saccharomyces kefir* and various *Torulæ*. Kefir is produced from either whole or skimmed milk. Four varieties, known as sweet, medium, strong and very strong, are prepared, the acid and alcohol content increasing with each variety. The dry grains are softened in water until they become white and gelatinous. One part of the prepared grains is added in 3 parts of milk which has been thoroughly heated to destroy its original bacterial content. The milk and grains are then placed in bottles, which are not stoppered but are covered with cloths or plugged with cotton-wool. These are stored at a temperature of between 57° and 68° F., their contents being frequently stirred and shaken. At the end of ten hours the milk is strained through a cloth and is filled into tightly-stoppered bottles which are stored at the same temperature, being shaken every few hours to prevent clumping of the precipitated casein. The product is ready for use after twenty-four hours. The fermentation temperature plays an important part in controlling the relative quantities of alcohol and lactic acid present. At temperatures above 60° F. the percentage of alcohol is increased ; at lower temperatures alcoholic fermentation is reduced, while the lactic-acid content is increased. Once the process has begun the kefir grains may be discarded, fermented milk being used in the ratio of 1 part to 3 of fresh milk. The grains may be washed, dried and stored in a dry condition for several years without losing their potency.

Koumiss

Koumiss is very similar to kefir and is produced from skimmed cows' milk to which lactose or whey has been added. A fermenting substance is added to the mixture, but once the process has started a portion of the koumiss can be used for treating the fresh milk. A small quantity of yeast may also be added for this purpose. Koumiss is a highly effervescent drink, containing several types of lactose-fermenting bacteria and yeasts. The lactic-acid organisms are closely allied to *Streptococcus lacticus*. Koumiss is less acid and dense but more alcoholic than kefir and has considerable food value. Its composition depends upon its age, the rapidity of fermentation and the nature of the causative agents. *Galazine* is a form of koumiss prepared from separated milk to which is added water, cane sugar, lactose and yeast. It is slightly acid and very effervescent but does not possess any therapeutic properties.

Yoghourt

Yoghourt differs from kefir and koumiss, being a thick curdled milk which is acid but contains little or no alcohol. It is a nourishing, easily-digested food prepared from milk to which cultures of *Diplostreptococcus yoghourt*, *Streptococcus thermophilus* and *Bacillus bulgaricus* have been added. After several days peptonising organisms also make their appearance. These produce partial proteolysis of the casein. This process increases the food value of the product. The milk is heated at 113° F., 2 per cent. of the liquid culture being added. The mixture is thoroughly stirred and filled into bottles held at the same temperature until coagulation takes place, usually after three hours. The product is then cooled, after which is it ready for consumption. Some moisture is lost by evaporation while the proteins are slightly peptonised, the greater proportion of the casein being curdled. The lactose is transformed into lactic acid. The acidity is considerably increased ; the fat and salts remain unaltered. As the lactic-acid content increases the action of the ferments is checked until it finally ceases. In the later stages a putrefactive process commences which disintegrates the protein substances. The consumption of yoghourt is said to exert a beneficial influence upon the bacterial flora of the intestines, whilst constipation, auto-intoxication and colitis are relieved. Putrefaction of the protein substances in the intestines takes place in an alkaline medium. From a therapeutic point of view the acidity is of great importance. Yoghourt should be taken medicinally when the acidity is increasing, i.e. between the first few hours after production and the following forty-eight hours. Yoghourt has been prepared in tablet form. The health-giving properties of these tablets are often so greatly impaired that they may be of little value.

Other Fermented Milks

Urda is a strong alcoholic beverage produced from sheep's milk and is sometimes known as "sparkling whey." A somewhat similar article is known as *skuta*, and is produced in Chile from the fermentation of whey and the addition of various saccharine and aromatic substances, chiefly lactose-splitting yeasts and bacteria.

Acidophilus milk is a cultured offshoot of yoghourt. This type of milk exerts a favourable influence upon the bacterial flora of the large intestine, while both constipation and diarrhœa are rapidly relieved by its use. It is palatable with an agreeable, mild acid flavour and is easily digested. It is prepared from milk which has been heated for one hour at 190° F., cooled to 100° F. and finally, after bottling, inoculated with a pure culture of *Thermobacterium acidophilum*. Approximately 1 per cent. of the culture is added to each bottle, which is immediately stoppered. The bottles are then incubated at 100° F. until coagulation occurs, usually within fifteen to eighteen hours. To obtain full therapeutic benefit the milk should be consumed within forty-eight hours, while the organisms are still vigorous.

Leben is prepared from milk fermented by the growth of yeasts and lactic-acid organisms. Its characteristic flavour is produced by the growth in milk of organisms which are not always necessary for the process of fermentation. *Kældermalk*, or "cellar milk," is a Norwegian product, produced by inoculating boiled milk with a special variety of ropy milk, the resultant product being stored under very cool conditions. Large quantities of lactic acid and alcohol are produced, which enable the product to keep well.

Buddeised Milk

This type of milk, which derives its name from the Danish engineer Budde, is treated for several hours during processing at a temperature of

125° F. with 0·35 parts per 1,000 of hydrogen peroxide. The milk is stirred during treatment, the hydrogen peroxide decomposing into water and oxygen and destroying the organisms. The quantity of chemical added depends upon the catalase content of the milk and the number of bacteria present. The hydrogen peroxide must be pure. This raises the cost of production beyond an economic level.

Iodised Milk

This is milk to which organic iodine has been added. Iodised milk has been prepared and marketed in the United States of America. Milk to which a 5 per cent. organic solution has been added has definite therapeutic value. The organic iodine is incorporated in the milk in the ratio of 1 gallon to 10,000 quarts, giving the milk an iodine content of 9 grammes per quart. This is sufficient to assist in the absorption and assimilation of the calcium, phosphorus and magnesium present in the milk, these elements being inadequately assimilated in the absence of iodine. The organic iodine passes readily from the digestive tract into the blood stream and exercises considerable power in combating plasma toxins and disease-producing organisms.

Dried Whey

Dried whey is manufactured by the methods used for drying whole milk, set out in Chapter XVII, pp. 259 to 262, the liquid being concentrated prior to drying by means of the roller or spray methods. A modified form of dough drying is also used, the whey being condensed until it has acquired a paste-like consistency. The paste is kept in motion in the drier by revolving arms. The stiff product which results is run into moulds, where it sets in the form of a crystalline cake, containing 10 to 18 per cent. moisture. The powder is then ground, and finally contains approximately 2 per cent. moisture. The utilisation of whey is of considerable value to cheese-makers. Dried whey is extensively used by bread bakers, the flavour, texture, colour and value of loaves being appreciably improved by its use. One gallon of whey produces approximately ¾ lb. of powder. This has a salty flavour, due to its high mineral content, approximately 2·5 per cent. of the whole. The mineral content affords a means of differentiation between dried whey and dried skimmed-milk powder. Dried whey is a white slightly sweet powder which will keep almost indefinitely if retained in a dry condition. It is extremely digestible and has a high lactose and phosphorus content. It is rich in vitamin G.

Lactalbumin

Lactalbumin is a nitrogenous substance resembling white of egg. It coagulates if heated to 158° F. and will not clot if rennet or acid is added. Lactalbumin yields many amino-acids, such as leucine, systine, glutamic acid and proline, on hydrolysis and is one of the most efficient growth supporters. It is obtained from whey and is used in many medicinal preparations. The whey is heated to 203° F. so that the albumin present coagulates. The substance is removed by filtration, ground with a measured quantity of deci-normal alkali and dried *in vacuo*. The dried product contains some 5 per cent. sodium hydroxide and is reasonably soluble in water. Hydrochloric acid is used to precipitate the sodium albuminate. The precipitate is thoroughly washed to remove all traces of sodium chloride, being afterwards dissolved in dilute alkali. The final product, which is readily soluble in water, contains some 2 per cent. sodium hydroxide.

Lactose

Lactose, or milk sugar, which is present in milk in quantities up to 5 per cent. of the whole and comprises approximately one-third of the total solids, is the principal product of whey. It is much less sweet than cane sugar, does not ferment and is particularly useful in medicinal preparations. It is regularly used for medical purposes in the form of tablets or pills and, since it is easily assimilated, is often employed in the preparation of humanised milk. It is also used in the manufacture of confectionery, and certain liquors. It acts as a check upon the action of putrefactive organisms in the intestines, since it provides nutriment for the fermentive types of bacteria and controls auto-intoxication. Lactose may be prepared directly from cheese whey or casein whey, or from filtration of the lactalbumin as mentioned above. If obtained direct from whey, the albumin is precipitated by heat, after which the liquid is mixed with calcium hydroxide and heated until a syrup is formed. This syrup crystallises in one or two days, the crystals being washed in a centrifugal machine and dissolved in hot water. The resultant liquid is heated to 170° F. and filtered through charcoal, the filtrate being dried at 140° F. and finally powdered. If the albumin is not removed from the whey the liquid is concentrated in vacuum pans, after which it is cooled and allowed to stand for twenty-four hours. A mass of fine crystals with a superimposed oily layer is formed. This is diluted with water and centrifugalised to separate the crystals. A crude yellow-coloured substance is obtained which contains 88 per cent. lactose. This is carefully washed in cold water and refined by mixing the crystals with bone black and a small quantity of acetic acid, the mixture being boiled. During the process 0·2 per cent. magnesium sulphate is added. The lactose is decolorised and deodorised. Albumin is precipitated by the acid, while phosphoric acid is precipitated by the magnesium sulphate. The liquid is filtered, concentrated under vacuum and recrystallised. It is then further refined until the lactose appears in the form of a very fine white powder. The production of lactose from whey has been greatly encouraged by its use as a medium upon which the mould *Penicillum notatum* can be cultivated.

Infant and Invalid Foods

Innumerable varieties of infant and invalid foods are prepared from dried whole milk, their mode of preparation differing only in a minor degree. The sale of proprietary infant foods has been very greatly reduced by the introduction on the part of the Ministry of Food of full-cream dried milk as a national infant food. *Cow and Gate* foods are available in full-cream, half-cream and humanised types, according to requirements. *Allenbury's No.* 1 food is composed of dried whole milk from which a certain proportion of the protein has been removed and to which lactose and cream have been added. *Glaxo* is dried whole milk with added cream and lactose. *Humanised Trufood* is modified dried milk in which the ratio of protein has been adjusted to approximately equal proportions of casein and lactalbumin plus globulin.

Of the invalid foods prepared from milk *Bengers Food*, containing wheat flour and pancreatic extract, may be mixed with whole milk. *Horlick's Malted Milk* may be similarly used. *Mellin's Food* is a type of desiccated malt extract. *Chocolate and Milk,* with or without added ingredients, is a popular invalid food, prepared by adding predigested wheat, sugar and chocolate to dried whole milk. It provides a nourishing and refreshing drink when reconstituted. *Ovaltine* and *Bournvita* are types of proprietary milk foods containing a percentage of malt.

Malted Milk

The preparation of malted milk combined the technique of dried milk production with that of the brewer. The process combines milk with the liquid resulting from a mash of barley malt and wheat flour. The *mash liquor* is produced from barley malt, which imparts a pleasing flavour, the highest-quality grain being required for proper germination and a sufficiency of enzymes. After cleansing to remove impurities, the barley is steeped in water for one to three days according to the type of grain, the water being frequently changed. It is then allowed to germinate. Germination, which takes place either on an open floor, in large tanks with perforated floors or in pneumatic drums, must not proceed too rapidly, time and temperature being equally important. When mechanical means are employed, the process occupies from six to seven days. Temperatures vary from 65° F. to 75° F. Germination produces an optimum percentage of diastases, for use in the rapid conversion of the starch into dextrins and maltose. Proteolytic enzymes are also formed. These break down the protein content of the grain into soluble and easily assimilable peptones and related bodies. Cystase, which is also developed, dissolves the cellulose tissue of the starch cells and releases the contents in a form on which the diastase can readily act. After germination the grain is dried in a kiln, the moisture content being reduced to 3 per cent. A drying temperature of 80° F. to 90° F. is maintained for the first few days. This is later increased to 120° F. for four days. If the drum system of germination is employed, the grain is dried in the drum.

The malted barley is crushed and mixed with wheat meal or flour, being afterwards "mashed" with cold water, the temperature of the mixture being gradually increased to between 160° F. and 165° F. The mashing process occupies several hours, the insoluble husk being removed by passing the mixture through a centrifugal separator. During the process the whole of the starch is hydrolysed by diastase into maltose, dextrin and malto-dextrins, while the complex cereal proteins are converted into simpler protein substances. *Mixing with milk* is carried out in vacuum evaporators, clean fresh milk being used for mixing with the mash liquor. This produces an article having a standard composition, strict analytical control being required. Reconstituted dried milk is not satisfactory for mixing with mash liquor, the final product lacking certain essential qualities normally associated with malted milk. The mixed liquids are subject to *dehydration* in evaporators provided with stirring gear. A high vacuum is maintained, constant agitation preventing excessive caramelisation and facilitating removal of the moisture. A final sponge-like swollen mass is formed. This is removed, reduced to a powder and packed. Care must be taken at this point to prevent reabsorption of moisture from the atmosphere. This will impair the keeping qualities of the product. Malted milk powder dissolves freely in either hot or cold water or milk, forming an extremely palatable beverage. It has an agreeable odour and flavour, both of which are derived from the hydrolysed cereal starch used in manufacture.

Casein

Casein is the most important albuminoid found in milk. Milk contains approximately 3 per cent. casein, which forms some 80 per cent. of the protein content of the liquid. Casein will coagulate when rennet or acids are added to milk, although it is not coagulated by heat as is albumin. It exists in a state of fine suspension and cannot be removed by ordinary methods of filtration. The quantity of casein obtained from milk is dependent upon the quantity of liquid used, the cleanliness of apparatus and utensils and accurate temperature control during processing. Acidity must be controlled to the proper end-point, while a well-washed curd with a low free-acid content must be produced. A maximum amount of moisture must be removed before the curd is milled and dried. Drying must be uniform ; suitable storage conditions after production are also important.

Acid-precipitated casein is obtained on a commercial scale from skimmed milk. The liquid is heated to 90° F., the casein being precipitated by the addition of hydrochloric acid. The milk is continuously stirred, the dilute acid (1 part of acid to 8 parts of water) being sprayed on to it until the milk breaks into clots, when the rate of stirring is increased. The curd is broken, half of the whey being drained off. Further quantities of acid are added until the mixture has a pH value of 4·6 to 4·8. The casein is drained into a cheese cloth and washed with acidified water, the process being twice repeated. After a final draining the product is pressed, milled and dried at a temperature of 120° F. to 125° F. Casein produced in this manner has a moisture content of 6 to 8 per cent. and contains between 1·4 and 2 per cent. mineral matter.

Rennet casein is prepared by warming skimmed milk to a temperature between 100° F. and 104° F. Rennet solution is added, the rennet being diluted to give a 4 per cent. solution. Approximately 10 millilitres are added for each gallon of liquid. Coagulation takes place after thirty minutes, the curd settling to the base of the vat. The curd is cut and the mixture heated to near boiling point to destroy the rennet. The whey is drained away and the curd piled, after which it is washed three or four times with cold water, drained, pressed, ground and dried. This type of casein contains between 5 and 9 per cent. moisture and approximately 8 per cent. mineral matter. The setting temperature, the kind, age and care of the " starter," the method by which it is added and the cooking temperature are all important factors. *Natural-soured casein* is produced from neutralised skimmed milk warmed to 104° F. and allowed to sour naturally until the acidity is 0·64 per cent. The casein is precipitated and cooked at 120° F., after which it is thoroughly washed, pressed, ground and dried. Casein should be stored in a dry atmosphere, protected from moisture, mould spores, vermin and insects. It is normally packed in jute sacks or in cardboard or wooden containers.

Casein can be used for a variety of purposes, the powdered type forming the basis of proprietary food preparations such as *Vitafer* and *Sanatogen*. Several of these preparations contain as much as 95 per cent. casein. A considerable business in hardened casein is now carried on, this substance being subjected to simultaneous pressure and heat and forming a substance which is the basic material of the plastic industry. Hardened casein is also used in the manufacture of imitation jewellery, in the production of highly-polished finishes on paper, in the manufacture of glues, as fillers for paint, for fixing colours in the textile industry and as an addition to insecticides. The disposal of acid or lactic-acid casein except under licence is prohibited.

Milk Chocolate

A large quantity of milk powder is used annually in the manufacture of milk chocolate, an average good-quality article containing 15 to 25 per cent. milk solids. No legal standard for milk chocolate is fixed in this country although in the United States of America the article must contain a minimum of 12 per cent. milk solids. The composition varies with different manufacturers. Continental chocolate usually contains a higher percentage of milk fat and lactose. Milk chocolate has a high calorific value, 1 lb. being equivalent to 1½ pints full-cream milk. When milk is in good supply it is dried for future use and may be stored as a highly-concentrated sweetened product, produced from milk to which 10 per cent. sugar has been added. The milk is evaporated to a concentration of 40 per cent. and is moulded into blocks which are covered with cacao butter. The dried or concentrated milk and cocoa mass are intimately mixed, ground and liquefied, being afterwards moulded as required, and later hardened. The food value of milk chocolate depends upon its constituents. *Cacao butter* is only slightly less digestible than milk fat, its digestibility being improved by the sugar in the chocolate. The presence of a high percentage of this substance will delay gastric secretion and may give rise to dyspepsia. The *proteins* in cocoa are mainly of the globulin type. Only one-third of the nitrogen is present in digestible form, soluble in the gastric juices. Another third is amino and alkaloidal nitrogen, the remaining third being non-assimilable. As with all cacao preparations, milk chocolate contains such *stimulants* as theobromine and traces of caffeine. Four ounces of chocolate contain 8 grains of theobromine, equal to a full medicinal dose. This is harmless. Theobromine is oxidised and broken up by the body into uric acid and other derivatives, which are excreted. It exercises a diuretic action and has a slight effect upon the cardiac muscle in addition to increasing the body's capacity for work. The gastric disturbances which can accompany the use of cacao products are thought to be due to the theobromine acting upon the gastric mucous membrane, with a subsequent delay of hunger and of the necessary secretions. The vitamins present are derived from the milk solids and the cacao mass. Chocolate contains an appreciable quantity of vitamin A. Vitamin B_1 has also been found, while experiments have shown that vitamin D is present in material concentration. In addition to its value as a food, milk chocolate can be used for improving the taste of laxatives and for coating pills.

Other Milk Preparations

Peptonised milk is prepared by adding pepsin to milk. The milk used for peptonising is usually diluted, as by this means the action of the clotting ferment is prevented. Peptonised milk is very digestible, the pepsin being added to hot or cold milk in the form of a powder. *Citrated milk* is often prescribed for invalids and is prepared by adding 1 to 2 grammes of sodium citrate to each ounce of milk. A finely-divided clot is produced. *Humanised milk* is very useful for infant feeding. It is prepared by the addition of water, cream and lactose to cow's milk. The usual proportions are 10 ounces cow's milk, 1 ounce cream, 1 ounce lactose and 10 ounces water. A close approximation may also be obtained by substituting whey in place of water, the quantity of whey equalling one-third of the volume of milk to be prepared.

Epidemiology

Of the subsidiary milk products mentioned in this chapter none have been the cause of outbreaks of infectious disease. It should be remembered that such outbreaks may occur, particularly if processing is not satisfactory and if contamination occurs after production before delivery to the consumer.

Control

The control of the manufacture of subsidiary milk products is equally important to that exercised in connection with any other foodstuff. The utensils should be maintained in clean and sterile condition, the premises should be suitable for manufacturing purposes and should be maintained in a thoroughly hygienic condition, while the health of the personnel should be above suspicion. The controlling official should pay particular attention to these points during any inspection of the premises and methods used.

CHAPTER XVII

CONCENTRATED MILKS

Condensed Milk

A considerable quantity of milk is concentrated in various ways in order to preserve it for future use. Concentrated milk contains all the constituents of milk in small bulk, with the added advantage of prolonged keeping qualities. At the beginning of the nineteenth century research was carried out both in this country and in France, various methods of concentrating milk being devised. Condensing only became practicable, however, when Borden, in 1856, patented a process for producing sweetened condensed milk. Following this discovery the industry developed rapidly. Apart from the production of concentrated types of milk in this country, large quantities are imported annually from abroad. Milk may be concentrated by condensing or drying ; condensed milk may be produced from whole or skimmed milk, sweetened or unsweetened. The unsweetened varieties are termed *evaporated milks*.

Manufacturing Methods

The production of condensed milk is a lengthy and complicated operation by reason of the delicate nature of the liquid milk and the easy manner in which imperfections may develop. The *raw milk supply* must be of high quality if the number of heat-resistant organisms is to be properly controlled. Supervision of production methods at the farm is important, great care being necessary to ensure that only milk of low acidity is used for processing. The incoming milk must also be free from any abnormalities in composition due to disturbed salt or protein balances or to the activities of bacteria. The milk is usually examined for fat, total solids, acidity, sediment and by reduction tests, while fermentation tests may also be employed. The liquid is filtered, cooled and run into storage tanks, where it is standardised by the addition either of cream or separated milk. The standardised milk is then ready for further treatment.

It now undergoes the process of *forewarming*, the object of which is to reduce the bacterial and mould content of the liquid and to destroy those enzymes which might encourage slow chemical deterioration in the finished product. Forewarming also helps to dissolve the sugar. Further, cold milk must not be fed to the vacuum pans, since it would settle to the bottom of the pans and become burnt. The temperature of forewarming varies from 145° F. upwards. A temperature of 200° F. is favoured in America ; in this country temperatures between 190° F. and 205° F. are used as an aid to reducing thickening of the finished product during storage. Moulds and their spores must be destroyed to prevent part of the sucrose in the condensed milk being inverted by their action. Various methods are employed for forewarming. The direct application of steam, although a simple method, cannot be recommended because of the possibility of contamination and the stale flavour likely to develop in the finished milk. Tubular heaters, various types of vats fitted with agitators and plate-heating apparatus are all employed. While some condenseries preheat the milk to a high temperature, experiments have shown that its pasteurisation by either the high- or low-temperature method represents a suitable means of forewarming the liquid. Although some changes are bound to occur, the food value of the milk is only slightly reduced.

The next stage is represented by the *addition of sugar*, the keeping quality of the finished product depending to a considerable degree not only upon the concentration but also upon the preservative action of the added cane sugar. Sugar is usually added in the ratio of 16 to 18 lb. for each 100 lb. of milk. The sugar should be pure and should not cause fermentation. The method of addition varies. The sugar may be added to the milk in a mixing pan in the form of a fine stream, agitation being employed. Sugar wells are more satisfactory. These are heated, small quantities of hot milk being run in and the sugar dissolved in the liquid. The sweetened and unsweetened milks are then mixed in a separate tank, from which the mixture is drawn to the vacuum pans. In this way the sugar dissolves without disturbing the state of solution of the milk constituents, the rate of evaporation being increased. The sugar is sometimes dissolved by boiling in water, the mixture being afterwards added to the milk. When this method is used, additional water must be evaporated from the milk. Boiling the solution destroys most of the organisms which may be present in the sugar and prevents the escape of undissolved sugar into the vacuum pan. The solution may be filtered to remove extraneous matters.

During the *condensing process* which follows, sweetened milk is usually condensed to 75 per cent. total solids, 2 to 2¾ lb. raw milk yielding approximately 1 lb. of the condensed liquid. The addition of 1½ volumes of water will thus produce a strength equal to the original. Several processes are available for condensation, the *atmospheric method* being popular with small producers. The milk is drawn into pans which have steam-heated revolving discs, the evaporated steam being carried away by fans. The food value of the product is often seriously affected, as a considerable degree of heat is required. This method has now been almost entirely superseded by the *vacuum-pan process*, used in most condenseries. The milk is condensed in stainless-steel coil or calandria pans provided with external or internal heating systems working under reduced pressure, the lower portion being steam jacketed. The pressure of steam is usually in the neighbourhood of 20 lb. per square inch. The operation is carried out at temperatures between 125° F. and 130° F., the milk boiling at this temperature owing to the reduced pressure produced by 20 to 25 inches of vacuum maintained in the pans. This prevents burning of the lactose and coagulation of the milk proteins. The pans should be sterilised before operations begin and the correct vacuum obtained. Milk is drawn slowly into the pans, each of the coils being heated as the milk rises. When the heating surfaces are covered, the inlet is partially closed to maintain the correct level of milk in the pan. Heated milk is drawn in continuously so that, when the last of the milk has entered, no more than fifteen minutes further processing are required before the desired concentration has been reached. The vacuum is then increased to 25 inches, the milk boiling vigorously. Towards the end of the period heating is reduced to prevent the thickened milk from burning. The condensed liquid is sometimes superheated before the pan is emptied. The vapour is condensed by means of water sprays, the temperature of the condensed water, usually in the region of 100° F., calling for careful control. Factors which may affect the speed at which the milk is condensed are: (*a*) the quantity of milk in the pan, (*b*) the area of the heating surfaces, (*c*) the capacity of the vacuum pump, and (*d*) the temperature of the condenser. The process usually occupies some three hours, a Beaumé hydrometer being used to determine the progress of concentration. When the reading shows 32° and the temperature of the milk is 120° F., treatment is complete.

When the *dry-air method* is employed, the milk is heated to 140° F., remaining at that temperature for two hours. Warm dry air is pumped through, producing considerable agitation and evaporating the water. This method has never been popular in this country. If milk is to be treated in a satisfactory manner with preservation of its colloidal equilibrium, it should not be heated to temperatures in excess of 140° F. Both coil and calandria type pans are employed. In the *coil type* the heating agent passes through the coils immersed in the milk ; in the *calandria pan* the milk circulates through vertical tubes. In both types the lower part of the pan may be steam jacketed. The vacuum pan is an airtight vessel which may be constructed of a variety of materials. *Copper*, which was formerly used, exerts a catalytic action on the milk, followed by oxidation, with the consequent appearance of a tallowy flavour in the product. *Aluminium* is excellent provided it is carefully cleaned, but has achieved little popularity. Neither has *tinned copper*, which is only satisfactory if the coating of tin is of suitable thickness and quality. *Stainless steel* and *glass enamel*, which are ideal for the purpose, enjoy universal popularity.

Low-pressure steam is employed as the heating agent, surface and jet condensers being used. Jet condensers may be either of the low- or high-level types. A copious supply of cold water is essential for condensing the vapour from the pans. Rapid evaporation is important. This demands the maximum rate of heat transference, which can only be obtained by rapid circulation of the milk. In the coil type pan milk circulation depends upon the hot milk rising and setting up circulating currents ; in the calandria type forced circulation is used, owing to the normal decrease in circulation as the viscosity of the milk increases. *Foaming* sometimes occurs following release of air in the milk. This trouble may occur in the sugaring wells, due to a portion of the air being driven out of the fresh warm milk when sugar is added. When the liquid is heated under vacuum, air is rapidly expelled from the solution, foam forms quickly and some milk may be carried over into the condenser if due care is not taken. Foam formation can usually be prevented by opening the air-break valves fitted to each pan. Two important factors governing the quality of the finished article are (*a*) the temperature of the milk and of the steam used for heating, which must be maintained at as low a level as possible, and (*b*) the period during which the milk is exposed to the heating surfaces. This should be reduced by evaporating at high speed. Continuous condensing is more economical and more satisfactory where large quantities of milk have to be handled.

Cooling must be applied when the milk is drawn from the pan if thickening is to be prevented and the texture of the product suitably controlled. The quantity of sugar which milk can carry in solution varies according to its temperature. As sweetened condensed milk is a highly-saturated solution of sucrose, the sugar crystallises out when cooling takes place. These crystals should be minute and never gritty. Rapid primary cooling is thus essential, after which the liquid should be cooled more slowly. Crystallisation is usually assisted by the addition of a small quantity of condensed milk taken from a previous batch. Various cooling methods are employed. Ten-gallon tapered pans immersed in running water and provided with agitation, pumping through coils immersed in running water, and vats containing revolving water-cooled coils are all used for cooling purposes. A combined vacuum pan and encrystalliser in which cooling is effected in the pan itself may also be employed, the final milk temperature being reduced to approximately 63° F.

After cooling has been completed, *packing* takes place, two types of container being used. *Barrels* with a capacity of 300 to 700 lb. are employed for bulk transport. These containers are often coated internally with wax to minimise the risk of contamination with mould spores. They should be steam sterilised before being filled. For retail sale the milk is packed in *cans* containing 8 ounces to 1 gallon, hand- or machine-filling being employed. The cans are either sealed with solder or crimped to form an airtight seal. Cans should be sealed immediately after filling, to prevent contamination by dust or flies and to ensure that no deterioration occurs following exposure to light and air. The cans are exhausted before sealing takes place, either the vacuum or atmospheric methods being used. After sealing, they are labelled in accordance with statutory requirements. The cans are normally given a superficial inspection which will reveal signs of indentations, rust or leaks. After a period of storage, they should be palpated to detect the presence of " blown," " swollen " or " springy " cans. These defects are produced by gaseous decomposition caused by heat-resistant yeasts which elaborate carbon dioxide from alcoholic fermentation of the sugar.

The *cleansing and sterilisation of plant* is vitally important. All internal surfaces should be given a primary washing with cold or tepid water, followed by hot water and detergent. They should receive a final sterilisation with steam or hypochlorite solutions. Any caked milk should be carefully removed. All pipe-lines should be dismantled and treated separately.

Defects in Condensed Milk

Defects occur in condensed milk due to the action of bacteria or to chemical or physical changes. *Bacterial defects* are mainly produced by organisms of the fermentation type. *Gassy fermentation* frequently occurs, gas being produced in the containers, which may burst through internal pressure. The milk becomes highly acid and will be lumpy and unfit for sale. The internal surfaces of the affected containers are usually discoloured and darkened. Organisms of the *Bacillus lactis aerogenes* type are particularly prone to produce gas in quantity. Although such organisms are destroyed by suitable forewarming, they may subsequently obtain entrance to the liquid following fly pollution. They do not grow in milk containing more than 40 per cent. sucrose, but may develop rapidly when the sugar has crystallised out. Gas-producing yeasts are also responsible for fermentation. *Torula lactis condensi* grows in media containing fermentable sugar and produces considerable quantities of gas. *Torula saccharalis* and *Torula globosa* also ferment condensed milk, with the evolution of gas.

Possible sources of contamination are many. The raw milk, the air of the premises and the condition of the apparatus used for cooling and filling may result in contamination ; the sugar used for sweetening may also be implicated. Only sugar of the highest quality should be used. It should invariably be stored under clean dry conditions. Inferior quality sugar often contains invert sugar, which encourages the growth of bacteria and yeasts.

If sugar is allowed to become damp and sticky it will attract flies and will encourage bacterial development. The growth of yeasts on utensils and plant follows unsatisfactory methods. The oxygen supply exerts a significant influence on the growth of yeasts. Most yeasts require a preliminary aerobic growth stage before they will develop to any extent under anaerobic conditions. Packing the milk in airtight or air-exhausted cans will therefore inhibit the growth of yeasts. Condensed milk frequently suffers from *bacterial thickening*, a defect which is most likely to occur at high temperatures. Cocci are most active in producing this defect, although the individual types responsible have not yet been completely identified. The responsible organisms are readily destroyed by the preheating process, although it must be remembered that the milk may become recontaminated from the plant or utensils during the remainder of the processing operations. As a preventive measure, a concentration of 64·5 per cent. sucrose is recommended. If the liquid is stored at reasonably low temperatures, this defect will not occur even when lower concentrations are employed. Some cocci do not ferment lactose or sucrose but coagulate the milk, due to the formation of a rennin-like enzyme. "*Buttons*" in condensed milk are caused by the mould *Aspergillus repens*, the defect occurring after lengthy storage. Small reddish-brown pieces of curd with a firm cheesy consistency are formed. These render the milk unmarketable although they do not affect the flavour. *Aspergillus repens* also produces a clotting enzyme which causes localised coagulation, the milk becoming contaminated during the concentration process in the absence of scrupulous care and cleanliness. The mould does not grow at low temperatures, while the exclusion of oxygen will assist in prevention. *Aspergillus repens* will not grow in cans which have been exhausted in a vacuum of more than 20 inches.

Several *non-bacterial defects* can occur in sweetened condensed milk. *Grittiness* is a condition in which the liquid contains large numbers of small hard crystals instead of possessing a smooth and homogeneous texture pleasant to the palate. This defect is due to the presence of sucrose crystals caused by faulty methods of cooling after processing. If grittiness is to be avoided, rapid initial cooling followed by slow cooling is essential, as has already been indicated. A type of *thickening* due to changes in the colloidal constitution of the albumin and casein also occurs and is due to processing factors. When albumin and casein are heated above their coagulation points, the effect upon progressive thickening is marked. The mineral salt content of the milk also exerts an important influence on thickening, while if the liquid is preheated at high temperatures there is a greater tendency to thicken. The degree of concentration further affects the tendency to thicken, this defect becoming more apparent as the milk solids are concentrated. Storage temperatures below 60° F. will reduce the chance of thickening. *Lumpiness* may occur, soft or cheesy lumps floating in the milk. The two commonest causes are (*a*) the concentration of raw milk which contains an unusually high percentage of albumin and globulin, and (*b*) the use of acid fluxes for sealing the cans. *Rancidity* is not often found. When this condition is present, the product is unfit for human consumption. One of the causes of rancidity is believed to be the high lipase content of the raw milk ; another is contamination of the milk by organisms which secrete lipase. Badly-polluted water which contains organisms of the *Pseudomonas fluorescens* type may also be a contributory factor. Rancidity develops between one and two months after canning and is at once noticeable when the container is opened. The contents become more viscous as the defect develops, until solidification occurs. The defects may develop if raw or improperly heated milk is drawn into the vacuum pan during concentration due to careless preheating. While sweetened condensed milk becomes darker in colour during storage, a *dark brown coloration* is sometimes noticeable. This is very probably due to the slow formation of humus consequent upon interaction between sucrose, lactose and milk protein. Acidity and temperature are additional factors which determine the rapidity of the colour change. The defect may be avoided if cans are stored at low temperatures.

Composition

Sweetened condensed milk to which sugar has been added as a preservative is a viscous fluid whose composition varies according to the type of milk used in manufacture. The whole-milk variety has a higher total solids and fat content, although the protein, mineral matter and lactose percentages are higher in the skimmed variety. Standards of composition are fixed so far as they relate to the percentage of fat (9·0) and the total solids content (31·0) in the full-cream variety, and to the total solids content in the skimmed milk (26·0). By an Order of 1940 (S.R. & O. No. 1622) *special full-cream sweetened milk* must contain 10 per cent. butter-fat. Slightly lower standards are in force in the United States of America. A higher ratio of condensation is therefore necessary in this country. More moisture must be removed, the final product being more viscous and more likely to suffer from " thickening." It should be noted that the increased viscosity limits the growth of certain types of organisms.

Nutritive Value

By reason of its small bulk and keeping qualities condensed milk is a convenient product for household and shipboard use and in the tropics. It is used for infant feeding, in the preparation of tea, coffee and puddings and as an ingredient for ice-cream, while it may be reconstituted by the addition of water to the equivalent concentration of raw milk. It is also used extensively by the chocolate and confectionery trades. In this country skimmed condensed milk must bear on the container the caption " Not to be used for Babies " in letters of suitable size. Heat treatment during processing is unlikely to cause any appreciable diminution in food value of the lactose, which, however, may be caramelised by excessive heating. The resultant change of flavour is often submerged in the sweetness produced by the added cane sugar. If condensed milk is diluted to reduce its sweetness, the food value is reduced, deficiencies appearing in the fat, vitamin and salts content. The proteins undergo little change during processing unless excessive temperatures are applied, when they will coagulate. The calcium and phosphate content may be affected by high-temperature heating, although the alterations in nutritional value are probably negligible.

The effect of the process upon the vitamin content is important. Vitamins are originally present in small quantities, while some are susceptible to heat and oxidation. Vitamins A and C are most affected, being easily damaged by oxidation. For this reason other foods which contain these vitamins must always be given to children in addition to condensed milk. There is little available information as to the comparable feeding values of condensed and raw liquid milks as a complete article of diet. Such an investigation might profitably be undertaken.

Bacterial Content

As sweetened condensed milk is not sterilised either before or after canning, reliance is placed upon its low moisture content and the preservative action of the sugar, together with the high solids content, to inhibit bacterial growth. Although even sound cans of milk are never sterile, they will remain in wholesome condition for months, and even for years. Apart from the organisms which escape destruction during processing, others obtain entrance from the atmosphere during cooling, and from the cans into which the milk is filled. Various types of *non-pathogenic organisms* have been isolated from condensed milk. *Staphylococci* may be present in large numbers, while *Staphylococcus aureus*, which grows in this type of milk with great rapidity, together with organisms of the *proteus* group are often found. Spore-bearers of the *Bacillus subtilis* group, *Staphylococcus fœtalis*, *Streptococcus albus* and *coliform organisms* may also be present, while *Bacillus mesentericus*, *Bacillus thermoin differens* and other heat-resistant organisms which have little or no public health significance have also been isolated. *Micrococci* may be present in large numbers and can rapidly multiply in the finished product. The *anaerobes* present are not an important cause of decomposition, as this type of milk is unsuitable for their development. The same applies to the coliform organisms. *Spore-bearing aerobes* are often found. Being actively proteolytic, they initiate decomposition in conjunction with *diplococci*. The heat-resistant organisms usually present do not cause decomposition. *Yeasts* may be plentiful. They either survive processing or are derived from the sugar, from the air or from the plant or utensils. Of the two types of yeast commonly found, the fermenting varieties are most significant, being responsible for gas production. Owing to the nature of the milk and the restricted oxygen supply, yeasts grow with some difficulty. If, however, they can secrete sufficient ferment to break down the saccharose before the oxygen supply is exhausted, their enzymes can produce gas. The fermenting yeasts are harmless to human beings but are likely to render the contents of the cans unsaleable. The milk should be sufficiently heated to ensure their destruction, while each batch of cans should be stored in a warm room for several weeks after production to ascertain whether or not any defects develop. It may be generally stated that, although non-pathogenic organisms are initially present in all cans of sweetened condensed milk, the viscosity and high sucrose content, together with the absence of oxygen, produce conditions unsuitable for development. It must always be remembered that the organisms present will multiply rapidly once the cans have been opened. The milk should therefore be consumed as soon as possible after a can has been opened if harmful results are to be avoided.

Pathogenic bacteria should not be present in condensed milk if it has been properly heated or pasteurised before evaporation. It has been shown, however, that *Mycobacterium tuberculosis* can resist some of the preheating methods used in manufacture. Any human pathogens added to milk after it leaves the vacuum pan quickly succumb.

Epidemiology

No definite outbreaks of disease have been traced to the consumption of condensed milk.

Control

Apart from the proper supervision of premises, plant, methods and personnel, the control of sweetened condensed milk is vested in the Public Health (Condensed Milk) Regulations of 1923 as amended in 1927. These regulations fix standards as to fat and total solids content and specify the labelling required. This type of milk must be labelled either " Full Cream Sweetened " or " Skimmed Sweetened," the latter type being additionally marked " Not to be used for Babies." *Bacteriological control* must cover both the incoming milk and the finished product. The incoming raw milk is examined for total bacterial count and coliform content. Dye reduction tests are applied and an estimation made of acidity and sediment. The milk is also subjected to fermentation tests. The condensed product is examined for total bacterial content and the presence of yeasts, while microscopic examination of the sediment is also made. Sweetened condensed milk is not sterilised and may contain large numbers of bacteria. No bacteriological standard is legally fixed. While the practicability of such a standard may be an open question, it would seem desirable, particularly as all the milk used during the process can be pasteurised as part of the forewarming treatment. *Chemical examinations* of the raw milk supply are confined to estimating the fat and solids-not-fat content. So far as condensed milk is concerned, the fat and total solids content is obtained to ascertain whether the milk satisfies the legal requirements. The ash and protein percentage is estimated together with the cane sugar content. Chemical examination of the finished product acts as a corollary to bacteriological analysis, and is also valuable from the nutritional standpoint.

Evaporated Milk

Unsweetened condensed milk is generally known as evaporated milk and is produced in practically the same manner as the sweetened variety, the process merely varying in certain minor details. No sugar is added as a preservative, this type of milk being nothing more than fresh cows' milk from which approximately 65 per cent. of the water content has been removed. Preservation is effected by sterilisation after concentration, the product being sold in hermetically-sealed cans in which it has been sterilised. Evaporated milk was first used in Switzerland in 1884, commercial manufacture being applied in the United States of America in 1885. The improvement of the vacuum pan introduced by Borden in 1856 simplified evaporation. Since that time many additional improvements have been made. Evaporated milk has proved of great benefit, large quantities being regularly imported into this country to be used in place of liquid milk. It is used for infant feeding, for consumption with canned or stewed fruit and on board ship, where supplies of fresh milk are often limited. Evaporated milk is a useful constituent of puddings and sauces due to its increased viscosity. It is also employed as an ingredient of ice-cream and artificial cream, while bakers, confectioners, sweet and chocolate manufacturers and restaurant keepers use large quantities. In America it has become an article of everyday diet.

Manufacturing Methods

The manufacture of evaporated milk is a lengthy process and is the same whether full-cream or skimmed variety is to be produced. *Preparation* is carried out in a manner similar to that required for the condensed variety.

A raw milk of high quality is a prerequisite if the resultant product is to be free from heat-resistant organisms. Low acidity is important. If the acidity of the final product is above normal it will clot during sterilisation and become unsaleable. The milk is tested by the usual methods, including fermentation and alcohol tests. The latter test is of particular importance, providing as it does the most convenient means of assessing the heat stability of the incoming milk. Coagulation of the liquid during the test implies a low heat stability and the milk should be rejected as unsuitable for processing. Heat stability is influenced by the relative quantities of mineral salts present in the milk. Milk which has an excess of calcium and magnesium salts in relation to the phosphates and chlorides present will have a low stability, the converse resulting in a highly stable milk. Other factors which affect heat stability are the acidity which has developed in the milk and its albumen content. After testing, the liquid is cooled and passed to storage tanks, where it is standardised to the required fat and solids-not-fat content.

Forewarming has already been described on pp. 244 to 245. The temperature employed is most important, because of the fact that the product is liable to coagulate during the sterilising process. The temperature at which coagulation occurs is influenced by several factors, of which this process is one. There is little or no correlation between the coagulability of the fresh milk and the evaporated article produced therefrom. The stability of the evaporated milk becomes progressively less as the solids are concentrated. The growth of lactic-acid organisms in the milk, with a corresponding rise in acidity, usually results in a lowering of the temperature of heat coagulation. If, however, the calcium content is lower than normal, the acidity which develops brings more calcium into solution and raises the coagulation temperature. The two main factors which control heat coagulation are the albumen content of the liquid and the balance of the mineral salts. The greater the albumen content the lower will be the temperature coagulability. The calcium and magnesium salts in milk balance the phosphate and citrate content. If the balance is in any way disturbed, the temperature of coagulation will be lowered. If the temperature of the milk is varied until coagulation occurs, calcium and magnesium are precipitated as phosphates and citrates, a visible curd appearing. The temperature stability curve of evaporated milk is the reverse of that of sweetened condensed milk, due to the effect exercised by the added sugar. The forewarming temperature varies, the process normally occupying twenty minutes. The milk is maintained under pressure so that it does not burn on the heating surfaces, high-speed circulation being essential. High temperatures naturally result in greater freedom from micro-organisms. Most samples of evaporated milk will survive a sterilisation temperature of 240° F. applied for fifteen minutes without coagulation of the contents. Sodium bicarbonate, di-sodium phosphate or sodium citrate may be used as stabilisers.

The methods of *condensing* closely resemble those employed in the production of the sweetened variety, with certain minor deviations. The degree of concentration in this country is greater than is required in the United States of America but is not so great as that required for sweetened condensed milk. Foaming occurs more frequently with this type of milk ; care must be taken to reduce this to a minimum. Concentration occupies some two and a half hours, the original raw milk being reduced 40 per cent. in bulk. The milk is generally prepared to a specific gravity of 1 : 10.

although this may vary in the light of the fat content and the desired concentration. Continuous processing is normally employed. A tubular type calandria pan is often used in preference to the normal coil type apparatus, widespread use being made of the thermo-compression system. The vapour given off by the boiling milk assists in the formation of the heating medium, the temperature of which is approximately 30° F. above the milk boiling point. Economy in the quantity of steam used for heating purposes is thus possible, while the tendency of the milk solids to coagulate on the heating tubes is reduced. As the rate of heat transference is lower, the calandria type pan is larger than the pan which uses high-pressure steam. Forced-circulation evaporators are also used and have many advantages.

Superheating of the milk is occasionally employed with a view to reducing the danger of coagulation during the sterilisation process. This method is applied to the milk when it is still in the vacuum pan or immediately after it has been drawn off, the object being to coagulate the albumen and precipitate part of the casein. Live steam is blown into the liquid until the temperature reaches 194° F. to 200° F. A flaky product is apt to result. For this reason the more modern method of homogenisation is usually employed.

Homogenisation breaks up the fat globules and effects an even distribution of the casein, lactose and albumen. This results in increased smoothness to the palate with an increase in digestibility and assimilation of the fat. Homogenisation is preferable to superheating, as contamination is greatly minimised. Pressures between 1,000 and 3,000 lb. per square inch are employed, two-stage homogenisation being occasionally used. Milk is homogenised in a warm condition at a temperature of 130° F. after it leaves the vacuum pan. This reduces viscosity and facilitates the process. *Irradiation* is sometimes practised after homogenisation to increase the vitamin D content.

The *cooling* of evaporated milk is entirely different to that required for the sweetened variety. As no crystallising precautions are necessary, the reduction of temperature should be as rapid as possible. The moisture content of evaporated milk, which is higher than that of the sweetened variety, is sufficient to keep the lactose in permanent solution. Various methods are employed. Whichever method is selected, due precautions must be taken to prevent contamination. The final temperature should be in the neighbourhood of 40° F. to 45° F. Sodium citrate or phosphate may be added after cooling at the rate of 0·025 per cent. to increase heat stability.

Filling and sealing of the cans should be completed as quickly as possible after the liquid has been cooled to 60° F., to reduce or prevent foaming. Unless the greatest care is exercised, contamination will readily take place during this process. The filling machines should be perfectly clean and free from stale milk, being thoroughly cleansed after each batch of milk has been handled. The cans are sealed immediately after filling. Great care is necessary at this point as the seals have to withstand the heat of the sterilisation process. The cans are usually soldered mechanically and are afterwards tested by being plunged into hot water. If a can emits bubbles or rises to the surface it should be discarded.

When filling has been completed, *sterilisation*, or *processing* as it is often termed, is carried out. This is intended to ensure permanent safety from bacterial development and to endow the milk with good keeping qualities. Temperatures well in excess of 212° F. must be used and maintained for a sufficient length of time, since all spores and vegetative forms must be killed. A temperature in the region of 240° F. is generally employed, although it should be remembered that too high temperatures or too lengthy processing at such temperatures will result in the formation of an objectionable hard curd, while the colour of the milk will also be affected. Three methods of sterilisation are employed, of which the *batch method* is most popular in this country. The filled cans are placed in racks in a large steam-tight boiler, the racks being moved by revolving mechanism which keeps them continually in motion. This facilitates uniform distribution of heat and breaks up any coagulum which has formed. A certain degree of coagulation is, however, desirable. This increases viscosity and so prevents fat separation. If the coagulum is not too thick and it is carefully broken up into a homogeneous liquid, the milk will take on a thick creamy appearance. Steam under pressure is used, the time and temperature employed depending upon the concentration, composition and seasonal character of the milk. Temperatures of 240° F. to 250° F. are normally employed, some fifteen to twenty minutes being required. The important factors are (*a*) the temperature attained, (*b*) the period during which the temperature is maintained, and (*c*) the extent of oscillation during the process. When treatment has been completed the cans are water-cooled and passed through an oscillatory apparatus which breaks up any curd formed during sterilisation, retaining the smooth homogeneous texture of the milk.

Continuous sterilisation is a comparatively recent development which is widely used in America. The cans are preheated and pass to the steriliser, which has a series of compartments maintained at different temperatures. The cans roll through the sterilising chamber on a spiral track, which ensures complete heat distribution. After treatment the cans pass to a cooler, which operates under similar pressure conditions to those of the steriliser. *Fractional sterilisation* has both advocates and critics but is still used on the grounds of low cost with satisfactory quality. The sealed tins are immersed in a water-bath at a temperature of 100° F., where they remain for eight hours, the water being allowed to cool gradually. Four hours after cooling, the water temperature is raised to 149° F. and held at this point for thirty to forty minutes. The cans are finally dried and passed to storage, being retained for two to three weeks in incubators or in rooms having a constant temperature of 80° F. This allows imperfections in sealing or in the sterilisation process to be detected. Fermentation is evidenced by bulging of the cans. Superficial and physical inspections are made, while selected cans may be opened for an inspection of the contents. Cans of evaporated milk may appear sound externally although, on opening, the contents may be sour or rancid. This defect is believed to be due to enzymes which have escaped destruction. If this defect is discovered, further cans from the same batch should be inspected. An efficient container can be made from well tempered steel plate with a satisfactory coating of tin. It should have double-seamed or soldered ends. When the cans are passed as satisfactory, they are labelled in accordance with statutory requirements and are packed for despatch.

Efficient *cleansing and sterilisation* of plant and utensils are vitally important (see p. 247 for further details). Evaporated milk may deteriorate or become unsaleable following the growth of undesirable micro-organisms. Such losses can be prevented by the employment of efficient means of cleansing and sterilisation.

Defects in Evaporated Milk

In common with all concentrated milks, evaporated milk can suffer from various defects, due either to the presence of abnormal organisms or to chemical or physical changes. The *bacterial defects* are mainly those which produce changes in taste. *Gassy fermentation* is caused by coliform organisms, *Bacillus cloacæ*, micrococci, coccoidal bacilli, spore-bearing anaerobes and gas-forming yeasts. The affected cans of milk become " blown " due to gas formation. Entire batches of milk may be affected. Organisms of the genus *Clostridium*, which are heat-resistant and spore-forming, may also play a part. These organisms produce gas with acid formation, the milk becoming putrid. They are distributed by means of dust, hay, straw or decaying matter. Strict cleanliness in the raw milk supply and factory methods, together with efficient cleansing and sterilisation of plant and utensils, will remove this danger. *Streptococcus distendens* is another cause of fermentation and acid production. *Coagulation* is often encountered, a hard curd being formed which shrinks and becomes surrounded with whey. The curd moves about when the can is shaken. The causative organisms include *B. coagulans*, *B. cereus* and *B. calidolactis*. The contents of the affected cans will have a bitter or cheesy taste. These organisms resist reasonably high temperatures. *Acid clots* caused by lactic-acid bacteria are sometimes met with, the result of contamination after sterilisation, due to faulty sealing of the cans. *Bitterness* occasionally develops. This causes marked acidity with a characteristically bitter taste. The responsible organisms are usually *B. amarus* or *B. panis*, both of which have a high thermal death point. Strict cleanliness in the factory, together with efficient sterilisation of the product after canning, are essential if this defect is to be limited. *Fishiness* has been reported in cans of evaporated milk due to the presence of *B. ichthyosmius*. This organism produces a fishy flavour and odour with increasing acidity. It usually gains entrance to the milk following inefficient sealing of the cans.

Non-bacterial defects of the chemical or physical type are chiefly concerned with alterations in the appearance of the milk. *Curdiness* occurs when milk which coagulates at low temperatures is sterilised. A hard curd forms which cannot be broken up and rendered homogeneous by shaking. The relevant factors are raw milk possessing a high bacterial content and excessive acidity, or milk containing organisms of the *Streptococcus liquefaciens* type, which produces a clotting enzyme. Excessive albumen content or faulty balance of the mineral salts may also produce this defect, while milk in which the total solids are highly concentrated curdles more readily than will a liquid having a low concentration. A *gritty sediment* is sometimes deposited at the base of the cans during storage ; this consists of calcium and magnesium salts and is formed during sterilisation. Less deposit occurs when milk is stored at reasonably low temperatures. Highly-concentrated milk deposits more sediment than do products of low concentration. Differences in the quantity of sediment deposited are due to fluctuations in the mineral content and salt balance. *Fat separation* seldom occurs, due to the high viscosity of the product, although this defect may be produced if the milk has not been homogenised. If a can of evaporated milk is shaken, the fat will be churned into masses, a liquid with large fat globules being particularly affected. An objectionable *brown colour* is sometimes found. The chief preventive factors are the temperature at which the milk is forewarmed and the addition of a suitable stabiliser. The sterilisation temperature should be as low as practicable, consistent with germicidal efficiency. Less difficulty is experienced with high temperatures for short periods than with the extended application of low temperatures. The use of sodium bicarbonate as a stabiliser is detrimental to colour. For this reason, sodium citrate or phosphate are often used in lieu. A forewarming temperature of 203° F. for a short period will not affect the colour of the milk after sterilisation ; a thirty-minute period will produce a considerable alteration. Colour production is reduced when the milk is homogenised prior to sterilisation, probably because the larger fat globules are broken down during the process.

Composition

Composition of the finished product varies according to whether or not it has been produced from whole or skimmed milk, although it might be mentioned that very little skimmed evaporated milk is manufactured in this country. Whole milk has an average total solids content of 32·53 per cent., made up of butter-fat (9·1 per cent.), ash (1·94 per cent.), protein (8·75 per cent.) and lactose (12·74 per cent.). The total solids of the skimmed milk variety averages 23·38 per cent., made up of lactose (12·5 per cent.), protein (8·35 per cent.), ash (1·78 per cent.), with only 0·75 per cent. fat. Under the terms of the Public Health (Condensed Milk) Regulations, 1923, evaporated full-cream milk must possess a butter-fat content of not less than 9 per cent., with a total solids content of 31 per cent. The total solids content of the skimmed variety must not be less than 20 per cent. of the whole. By an Order issued in 1940 (S.R. & O. No. 1622) *special full-cream* unsweetened milk must possess a butter-fat content of not less than 10 per cent. In the United States of America the fat content of evaporated full-cream milk must not be less than 7·8 per cent., and the total solids content not less than 25·5 per cent. The total solids content of the skimmed variety must not be less than 20 per cent. During the War emergency legislation permitted a reduction in Great Britain to the American level.

Nutritive Value

Evaporated milk will keep indefinitely as a result of the sterilisation process. The essential facts relating to the food value of sweetened condensed milk set out on pp. 249 to 250 apply with equal force to evaporated milk. Certain additional facts, such as the changes brought about by the high temperatures reached during certain phases of the process, merit consideration. The lactose is often caramelised or burnt during sterilisation, producing a brownish tinge and imparting a characteristic flavour. The absence of added sugar lowers the food value, although the nutritive value should not be essentially different from that of raw milk. The fat globules, which are reduced in size, are rendered more digestible owing to the homogenisation process, while the milk proteins are coagulated by the temperatures reached. There is little evidence to show that this coagulation exerts any detrimental influence upon the product or that it affects digestibility in any way. It is, indeed, possible that heat coagulation increases the digestibility of the proteins. Vitamin C is probably the only vitamin to be seriously affected by the process, being most susceptible to oxidation. Vitamin B_1 is reduced by some 20 per cent. Vitamins A and D are present in the quantities originally found in raw milk, while vitamin G is retained at full strength. Evaporated milk is a valuable food for infants but it is not complete in itself, requiring the addition of orange or tomato juice, or their equivalents, together with lime water or barley water, to provide an adequate composite diet. The homogenisation process produces minute globules of fat characteristic of human milk, while the curds are small and flocculent, being easily digested and assimilated. The fact that evaporated milk should be sterile is an additional advantage. Unfortunately, this is not always the case. Evaporated milk contains proteins and mineral salts, while the whole-milk type contains abundant fat in an easily assimilable form. This type of milk has been found useful in cases of colitis and other digestive disorders in adults. It is also assimilable by individuals who are allergic to raw milk. Evaporated skimmed milk must be labelled " Not to be used for Babies."

Effect of Heating

The general effect of the heating process on milk has already been discussed on p. 155. Higher temperatures are used in the preparation of evaporated milk than is the case with most other milk products, the aim of the manufacturer being to produce a sterile foodstuff. Approximately 80 per cent. of the cans will normally be found to be sterile, it being a comparatively easy matter, given the requisite time and temperature, to produce a sterile article which will keep indefinitely in a sealed can. In practice, the manufacturer has no wish to over-process the liquid, since, because of the differences in sterilisation temperatures, the product may become either coagulated or useless, while its food value may be entirely destroyed. A tendency to underheat therefore exists. Because of this, sterility must never be presumed. Up to 20 per cent. of cans have been found to contain spore-forming bacteria which survive the processing temperatures although no outward signs of decomposition were evident. The chemical changes discussed on pp. 249 to 250 also occur. The lactose is caramelised and becomes brown in colour at temperatures of 175° F. and above, imparting a light buff colour to the milk.

Bacteria in Evaporated Milk

The bacterial problems of evaporated milk are entirely different from those of the sweetened condensed variety. If properly processed, the final product should be sterile. Only those organisms which are highly resistant to heat are likely to survive the process. Sterility and keeping quality depend upon the heat treatment provided. If spore-forming or heat-resistant organisms are present in the original milk it is possible that at least some of these will survive and multiply in the final product during storage. The most important stage in the treatment of evaporated milk in relation to the destruction of micro-organisms occurs during the sterilisation process. The temperature of the interior of the steriliser is usually checked by thermometric methods, but no guarantee can be given that the contents of each can reach the required temperature, or that they are held at that temperature for the requisite period. Cans to which maximum thermometers are fitted can be distributed throughout the apparatus and will indicate whether or not the optimum temperature has been reached. They will give no indication, however, of the time during which the contents of that particular can have been held at that particular temperature. A time-lag exists between the attainment of the external and internal temperatures of the can and its contents, the extent of this lag being greater than is generally realised. This may result in the cans being held at the optimum temperature for only a short period. Faulty sealing of containers may be responsible for bacterial spoilage after sterilisation. The sealing may not be tested in every case, occasional cans being overlooked. This should never be permitted.

Various types of organisms have been isolated from cans of evaporated milk. *Aerobic spore-forming bacteria*, which will develop in evaporated milk but do not readily exhibit activity, have been found both in sound and unsound cans. They are of little importance unless present in excess. Their normal inactivity is due to the colloidal changes resulting from concentration and sterilisation. *Anaerobic spore-bearing organisms* are infrequently the cause of decomposition. While of little importance in themselves, they may cause decomposition in conjunction with other orgaisms. *Gas-forming aerobes* are not found in sound samples of evaporated milk ; coliform types and *B. cloacæ* cannot grow in or decompose evaporated milk, although they can produce gas and cause the milk to clot. *Thermophilic organisms* are rarely found and have little significance ; *yeasts* have occasionally been isolated from sound and unsound cans. *Non-fermenting types* are of little importance. The presence of *fermenting species* will result in " blown " cans. *Micrococci*, principally diplococci or streptococci and occasionally staphylococci, have been isolated from sound and unsound containers. Their presence may result in the production of carbon dioxide gas. Some of these organisms cause the milk to deteriorate, with the production of acidity, frothiness, blowing of the can, bitterness, clotting and, in some cases, a cheesy odour. *Coccoidal bacilli* which may produce sufficient gas to blow the containers have also been isolated from unsound cans. If bacteria are present, they will multiply rapidly under suitable conditions when the can has been opened.

Epidemiology

No outbreaks of disease have been traced in this country to the consumption of evaporated milk, although cases of botulism have been reported from the United States of America due to the consumption of spoiled canned milk infected with *Clostridium botulinum.*

Control

The control of evaporated milk production must include premises, plant, utensils, methods and health of the personnel. As with sweetened condensed milk, *legislative control* is vested in the Public Health (Condensed Milk) Regulations, 1923, as amended by the Regulations of 1927. This type of milk must be labelled " Condensed Full-cream Milk, Unsweetened " or " Condensed Skimmed Milk, Unsweetened (Not to be used for Babies)," as the case may be. *Bacteriological control* of the incoming milk and of the finished product, together with *chemical control*, is similar to that already outlined on p. 251 for the sweetened condensed variety. No legal standard exists in regard to the bacterial content of evaporated milk. This is a serious omission, since the milk should be sterile if efficiently processed.

Dried Milk

Dried milk is produced and sold in large and increasing quantities, principally as a basis for the many varieties of infant foods available. Shortages of liquid milk since 1939 until recently also encouraged its widespread use for culinary purposes. Bakers and confectioners, ice-cream manufacturers and makers of animal foods use large quantities, while it is very useful on board ship and in the tropics. Liquid milk contains a high proportion of water, is bulky to transport and is extremely perishable. The drying process ensures that the milk solids are available as a dehydrated powder which can be stored without spoilage for lengthy periods. The preparation of a perfect dried milk would solve to an appreciable extent the difficulties experienced by milk distributors consequent upon seasonal surpluses and shortages. Many authorities are of the opinion that the future of the milk industry will tend towards the drying of milk on a more extensive scale. The quantity of powder obtained from raw milk depends very largely upon the quality of the raw milk supply. On an average, full-cream milk produces $1\frac{1}{4}$ to $1\frac{1}{2}$ lb. of powder per gallon ; approximately 1 lb. of powder per gallon can be obtained from separated milk. Dried milk was originally produced from separated or skimmed milk, lengthy storage of the full-cream product often causing rancidity. Modern developments in technique have now made it possible to produce a dried whole milk which can be stored almost indefinitely. Dried milk was originally produced by Appert in 1810, although it was not until 1855 that the first commercial drying process was evolved.

Manufacturing Methods

The drying process aims at removing almost the entire moisture content of the milk by evaporation, the result being a dry powder which includes the total milk solids reduced in bulk, thus facilitating transport and storage. When reconstituted with water, a perfect milk powder should give a fluid identical in every way with fresh milk. In practice very few powders reach this high standard. A good spray-dried milk powder should be 100 per cent. soluble ; roller-dried powders with a *solubility* of 85 per cent. are regarded as satisfactory. Insolubility is due to the application of excessive heat during the drying process, causing the colloidal constituents of the milk to become denatured and inert. *Keeping quality* is important. High-quality roller-dried powder will keep from six to twelve months without deterioration in the form of rancidity or tallowiness. Rancidity usually develops most quickly in whole-milk powder. The spray-dried product generally has a keeping quality of three to seven months. *Nutritive value* depends upon the type of milk treated and the process used, although no method of processing should destroy the valuable properties available in the original whole milk.

Preparation of the milk follows normal lines. Clean milk from healthy cows in fresh condition should be used. The usual bacteriological and chemical reception tests as to quality are applied. The liquid is filtered, cooled and pumped into storage tanks, where it is standardised according to the type of powder required.

Two main *drying methods* are used. *Film drying* by means of rollers or band-film apparatus is occasionally employed, but it is not so popular as *atmospheric roller drying*, first carried out in this country in 1855. The milk is often subjected to *pre-concentration in vacuo* before being fed to the rollers. This improves its quality, although the process is not essential. Continuous-operating thermo-compression evaporators are used for this purpose. Pre-concentration may be carried out before any method of drying is used. The *feeding of milk to the rollers* follows, simultaneous preheating being frequently applied. When milk is fed to a single roller, the drum may be immersed in the milk. This is only possible where the liquid has received prior concentration. Owing to the low viscosity of milk in its normal state, it is difficult to obtain a satisfactory film while ebullition is set up, the latter phenomenon tending to produce lumps of fat on the surface of the milk. The resultant powder will vary in quality. A feed tray is more commonly used, the thickness of the film being controlled by the level of the milk in the tray. With double-drum driers the liquid milk may be fed into a trough formed between the two rollers or may pour in a thin film over spreaders, which direct the milk to the rollers. Milk may be sprayed on to the rollers or may be fed in the form of fine drops. Provision is usually made for the milk to be preheated by the vapour which rises from the rollers. Whichever method is employed, the liquid should not come into contact with the rollers until it is in film form and capable of being rapidly dried. It should also be preheated by the vapour rising from the process. It is important, however, that the milk powder should not come into contact with such vapours.

Methods of atmospheric roller drying vary. The milk is spread in a thin film on revolving steam-heated rollers. After evaporation has taken place the dried powder is removed by knives. The rollers are exposed to the atmosphere. From the point of view of installation and operation this is the most economical method. Both single- and double-cell driers are employed, the apparatus being massively constructed and secured to an adequate foundation to avoid vibration. Drum speeds do not usually exceed sixteen revolutions per minute, otherwise the scraper knives will " chatter " as the drums revolve. The usual type of knife has one long blade, which is adjusted to give uniform pressure. Any variation in pressure is easily noticed since, as if the powder is not completely removed, it will adhere to the drum, when a brown streak will be visible. The milk powder may either be brushed off or recovered by knives. As the drums and blades are continually wearing during use, metallic dust may become mixed with the milk powder, a danger which is obviated when brushes are used.

Steam is used for heating the drum. The steam pressure is maintained at constant level, no milk being fed to the rollers until they have been thoroughly heated. The film temperature should not fall below 212° F., the full effect of the heating surfaces being felt during the latter part of the revolution. Because of this a blast of cool air is sometimes employed at this point to avoid overheating the powder. To prevent damage to the delicate milk constituents, the drying period should be reduced to a minimum, the denaturing influence of heat on milk being proportional to the period of exposure to the heated surface. The film of milk is kept as thin as possible, the drying process usually occupying two and a half to three seconds. Varying steam pressures, up to 100 lb. per square inch, are used within the drums. Drum speeds are normally increased when the higher pressures are employed. Superheated steam is sometimes used to reduce the quantity of condensate in the drum.

At the end of the run the drums are cleaned with water and thoroughly wiped. A thin layer of vaseline is usually applied to their surfaces to maintain the polish. Roller plant is simple to operate, reasonably economical to install, while steam consumption is low, very little power being required to drive the rollers. The main objection to the method is the fact that the milk film is heated to a temperature which seriously impairs the solubility of the final product. This rarely exceeds 85 per cent. The moisture content of the powder as it comes from the rollers should not exceed 2 per cent.

Vacuum roller drying is a great improvement on the atmospheric roller method. The underlying principle is similar although the rollers are enclosed in a chamber in which a vacuum is maintained. By this means the rate of evaporation is increased, while drying operations are carried out at much lower temperatures, approximately 100° F. to 104° F. The moisture contained in milk is quickly evaporated, the degree of vacuum maintained being approximately 28 inches. This type of apparatus is more costly than the atmospheric drier of similar size, while operating costs are increased. Prior to drying, the milk is normally concentrated to 40 per cent. of the solids to reduce operating costs. Oxidation of the milk in the atmosphere is reduced by this process. There is a sterile inert atmosphere in the drying chamber, the food value is maintained, while an easily-soluble product is produced. The plant is compact and processing can be closely controlled. Difficulties in inspecting the product during treatment do arise, while any defect in the film is difficult to correct. It should also be stated that the plant is somewhat inaccessible for cleansing. *Band-film drying* is a development of the roller process, the milk being spread in thin layers on trays. Drying is carried out by means of hot air in a closed chamber. Alternatively the liquid may be spread on an endless band which passes through a heated chamber in which a vacuum is maintained.

Spray drying provides for rapid evaporation of the milk at comparatively low temperatures, a high-quality product being obtained. This is the most costly method of treatment. Pre-condensed milk is atomised and sprayed into a stream of hot air, which evaporates and carries away the moisture, the milk solids being deposited and collected in the form of a fine powder. The milk temperature may be kept below 140° F. ; dehydration is practically instantaneous. Pre-concentration is carried out in vacuum pans to 40 per cent. solids with a 23-inch vacuum. This makes for heat economy in the drying plant and increased rapidity in processing. Milk powder produced from pre-condensed milk is coarser than that obtained from fluid milk. It is more easily miscible in water and more readily collected and packed. Powder from milk which has not been pre-concentrated has a light fluffy texture and is difficult to moisten because of its fineness. Pre-concentrated milk is often homogenised before being dried, although the process is not general to all spray-dried milks. The methods employed for drying vary. Drying chambers may be square, rectangular or conical. The milk enters at any desired point, meeting a stream of hot air which dries the fine droplets of liquid fed into the chamber from the atomiser. The atomiser must supply liquid particles of uniform size, the direction of spraying must be capable of control and the atomiser must be able to work for long periods. Three types of atomiser are employed, varying according to the type of plant. They are of the pressure spray, disc and compressed air types. The purity of the air supply is important. The air should be washed and filtered before use. The powder may be removed from the drying chamber either by means of rakes, brushes, suction or in settling chambers. A certain amount of powder—often up to 20 per cent. of the whole—may be carried forward by the air leaving the drying chamber. Various types of filter bags are therefore used to collect this powder. These bags should be sterile. A method of precipitation has also been employed for the collection of powder carried forward in the air stream.

As soon as the powder has been collected *preparation for sale* follows. The powder is first allowed to cool and is then sifted by passing through fine gauze cylinders in which a spiral brush revolves. This process removes small quantities of insoluble powder and standardises the texture. After sifting, the powder is examined for flavour, fat, moisture, bacteria and solubility. It is then blended to the required standard and weighed into containers. These are usually of metal and are made in various sizes, the powder being generally untouched by hand. Bulk consignments are packed into barrels or metal-lined boxes. Inert gas and vacuum packing are employed with a view to prolonging the keeping quality. The addition of anti-oxidants has also been tried with satisfactory results, while nitrogen, which must be of maximum purity, fulfils a similar function.

Defects in Dried Milk

Several factors adversely affect the appearance, keeping quality and value of dried milk, causing decreased solubility, rancidity, tallowiness, stale flavour, offensive odour and, in some cases, the development of a brown coloration. If powdered milk is properly produced and maintained it should contain very few bacteria. Because of the low moisture content, such organisms as are present will normally decrease during storage. Bacteria are able to multiply if the moisture content is excessive, causing the powder to decompose. With a moisture content of more than 5 per cent. a much greater tendency exists for milk powder to develop staleness and offensive odours, while its solubility will be decreased. *Tallowiness*, which sometimes develops and is caused by oxidation of the fat, is influenced by several factors, principal among which are the fat and moisture content, the presence of metal catalysts and atmospheric conditions during storage. A high fat content tends to accelerate the development of tallowiness, but the opposite holds with the spray-dried product. This defect appears earliest in powders which have a low moisture content, irrespective of the type of powder. The optimum moisture content for spray-dried powder is 3 per cent., and for the roller dried variety 2 per cent. The presence of metal catalysts such as iron or copper, which may obtain entrance to milk from utensils or plant, will accelerate oxidation of the fat and cause tallowiness or rancidity. The atmospheric conditions under which the powder is stored also influence the development of tallowiness. High temperatures hasten the development of stale flavours and offensive odours and cause loss of solubility. *Rancidity* develops in accordance with the heat treatment employed and depends upon whether or not the lipase content is destroyed. Spray-dried milk is most likely to suffer from this defect owing to the lower temperatures employed. Containers should be efficiently sealed to prevent the entrance of air and moisture. Sugar is sometimes added to the powder to give a protective coating to the milk particles. This is useful in preventing defects and improves the keeping quality.

Composition

The composition of dried milk depends on the quality of the raw liquid used in manufacture and also on the effect of processing on the removal of moisture, both of which are variable factors. The composition is not governed by any general standard. As a result appreciable variations are met with, although the fat percentage must comply with the standard laid down in the Public Health (Dried Milk) Regulations, 1923, as amended by the Regulations of 1927. The fat content of full-cream dried milk must not be less than 26 per cent. ; of three-quarter-cream milk, 20 per cent. ; of half-cream milk, 14 per cent. ; and of quarter-cream milk, 8 per cent.

The total solids-not-fat content of dried skimmed milk must not be less than 9 per cent. National dried milk, manufactured since 1940 by the roller process, must have a butter-fat content of 26 to 27 per cent. in the full-cream powder ; the fat content of the half-cream powder must be 16·5 per cent. Lactose, protein and ash are present in varying quantities, higher percentages being present in the part-skimmed and skimmed varieties. The moisture content should not exceed 3 per cent. Some dried milks contain added sugar ; alkali is added to others to improve solubility. The ease with which dried milk may be reconstituted varies considerably. The chemical and physical properties of the milk solids may be changed to such a degree during the process that subsequent mixing with water will produce a fluid which does not even remotely resemble milk.

The solubility of the powder is tested by floating a small quantity on the surface of water in a test-tube. If the powder is readily soluble, white milky streams will begin to flow downwards, the water quickly taking on the appearance of milk. Powders of poor quality will not disperse so readily, the water remaining relatively clear. The solubility of roller-dried powder varies between 70 and 80 per cent. ; that of spray-dried powder varies between 90 and 100 per cent. The insoluble content is increased by contact with moist air or by storage at high temperatures. Roller-dried powder is darkest in colour ; brownish tints indicate excessive drying temperatures and caramelisation of the milk sugar. Spray-dried powders have spherical grains ; the grains of roller-dried milk are irregular in shape. The fat of roller-dried milk is present in the form of large drops, while the fat of the spray-dried variety appears in small globules. Spraying under pressure affects the fat globules in a similar manner to homogenisation. Rennet coagulates roller-dried milk irregularly, exerting an effect on spray-dried milk similar to that which occurs when it is added to fresh milk. The peroxidases are not affected by spray-drying.

Nutritive Value

Dried milk is not generally sold as a milk powder, being disposed of in the form of infant and invalid foods, of which it forms the basis. It may be either sweetened or unsweetened, while vitamins or lactose may also be added. The effect of processing upon its nutritive value should be as harmless as possible consistent with commercial requirements. The food value of dried milk is similar to that of the condensed and evaporated varieties (see pp. 249 and 256) with certain modifications. The lactose content is often artificially increased prior to drying. The type of protein insolubility which occurs in dried milk differs from the heat denaturation which affects the evaporated product. Overheating is likely to occur during the roller process, as the internal temperature of the rollers often reaches 320° F., particularly in the later stages of the process, when the mass is in a semi-solid condition. Any deficiency in mineral content can be made good by direct addition of the necessary salts prior to manufacture. On the whole the mineral salts in milk are well balanced, although there is usually a deficiency of iron and copper. Such salts could be added to the liquid milk, although it must be remembered that excessive additions might do harm by reason of their catalytic action in oxidising the milk fat. The effect of heat upon vitamins has already been considered. It is claimed that the heating process is of such short duration that the vitamins are not seriously affected although there is a loss of about 10 per cent. in vitamin B_1 and 20 per cent. in vitamin

C. Tests in the feeding of school children with dried milk in addition to their normal diet, and in comparison with pasteurised and ordinary raw milks, have shown that the group fed on a normal diet plus roller-dried milk showed the greatest average gain in height and weight, the gain in height being particularly marked. The dietetic value of dried milk is at least as high as that of liquid milk, while its bacterial content should be negligible. There is evidence to show that dried milk lacks nothing which the original milk contains, while in addition it has advantages peculiarly its own. Dried skimmed milk must be labelled " Not to be used for Babies."

Effect of Heating

The effects of heat on milk have already been discussed on p. 155. Very high temperatures are often reached in the manufacture of dried milk. If these temperatures are applied for a lengthy period the milk is likely to be affected. Roller-dried milk usually exhibits a caramelised flavour. This is absent from the spray-dried variety, although localised overheating at the base of the drying chamber may produce a slightly cooked flavour in this type of spray-dried milk.

Bacteria in Dried Milk

If properly processed, dried milk should contain very few bacteria, provided the initial raw milk has a low bacterial content and provided the dried product is adequately protected from contamination after manufacture. Most of the organisms which survive the drying process are of the spore-bearing variety. Lack of proper handling may result in contamination with other varieties of bacteria, yeasts and moulds. When purchased, dried milk is seldom sterile, although the product usually contains insufficient moisture to allow those organisms present to multiply to any appreciable extent. If stored in a damp atmosphere, the powdered milk will absorb sufficient moisture to allow moulds to develop. If the dried milk is suitably stored, the number of organisms present tends to decrease during storage. *B. mesentericus vulgatus*, *B. mesentericus ruber*, *B. cloacæ*, *B. mycoides* and *B. subtilis* have all been isolated from reconstituted roller-dried milk. It has been stated that any tubercle bacilli present may escape destruction if the milk is not properly processed, although their virulence will be greatly reduced. Other pathogens appear to be totally destroyed during treatment. All organisms which survive roller drying may also survive spray drying. The bacterial content of a dried powder manufactured under suitable conditions from an originally pure milk supply should always be low. For this reason any deviation from the normal accepted standard should be viewed with suspicion.

Epidemiology

No definite outbreaks of disease have been traced to the consumption of dried milk in this country. In America a special type of milk powder, known as protein milk, was responsible for an outbreak of enteritis in Chicago during 1928. Eighty-eight babies became ill, of whom twenty-seven died. The mode of entry of the organisms was never discovered although the outbreak was found to be due to the Morgan bacillus. When proper prophylactic measures were put into force the outbreak subsided. The total bacterial content of the powdered milk was high, with a particularly heavy streptococcal infection.

Control

Control measures aim at inspection of the raw milk, plant and methods, together with supervision of the health of the personnel. Legal control is based on the Public Health (Dried Milk) Regulations, 1923, as amended by the Regulations of 1927. These include certain chemical standards applicable to the product as already mentioned, with methods of labelling. This type of milk must be marked " Dried Full Cream " or " Dried Skimmed Milk (Not to be used for Babies)," according to type. *Bacteriological control* of the incoming raw milk must make use of the normal standard tests. It is particularly important that samples of dried milk should be obtained and maintained in a moisture-free condition, owing to the effect which the presence of moisture has upon bacterial development. *Chemical examinations* follow the usual lines. The examination for sediment in the dried product, together with its moisture and protein content, are of considerable importance. The quantity of sediment indicates the solubility of the powder under test.

CHAPTER XVIII

BEVERAGES

ALTHOUGH beverages, which include tea, coffee, cocoa, beer, wines, spirits and soft drinks, are not foods within the strict meaning of the term, they merit consideration in any volume dealing with food hygiene. Large quantities of beverages of one kind or another are consumed annually in practically every country in the world. Careless or faulty methods of production may lead to contamination of the liquids and may thus be the cause of ill-health. Certain forms of adulteration have also been practised. The methods used in production and processing should be known so that danger from either of these sources may be eliminated.

Tea

Tea is the description given to the leaves of the tea plant when they are prepared as a beverage by infusion with boiling water. The tea plant is an evergreen bush which grows in the moist sub-tropical regions of India, Ceylon, China, Japan and in neighbouring countries. The seeds are germinated ; when the shrubs are some 6 to 12 inches high, they are planted in open fields in rows approximately 4 feet apart. The height of growth is restricted to a maximum of 4 feet, the limit being determined by climate, locality and the pruning which the plant receives. The leaves can be picked three to four years after planting, the period varying according to soil conditions, rainfall and sunlight.

Black and green varieties of tea exist. These are produced from the same leaves, differences in preparation causing the variation in colour and flavour of the finished article. Both types are subjected to the processes of withering, rolling and firing. When *green tea* is manufactured, the leaves are withered by the use of dry artificial heat or by steaming at a temperature below 212° F. This process renders the leaf soft and flaccid. Artificial drying is necessary with this type of tea in order to prevent the development of enzymes. The leaves are then rolled. Many of the contained cells are broken down to liberate juices. The bursted leaves, or " rolls " as they are termed, are piled into heaps and allowed to heat spontaneously for a short period. The " rolls " are passed through a breaking machine, following which the broken material is sifted through a wire mesh into a cloth container. The leaves are next spread thinly on wire trays or moving belts and are aired by a current of air at temperatures between 190° F. and 240° F., usually in drying chambers. The green colour and the flavour are retained by this method of treatment. The material is finally sorted by sieving and packed. In some instances it is again roasted after grading and before packing.

When *black tea* is prepared, the material is first allowed to wither for eighteen to thirty hours in the slightly humid atmosphere. This process assists the development of the enzyme, an oxidase, the young leaves containing the greatest proportion of this substance. The material is then piled into heaps and allowed to ferment for several hours. This fermentation is of particular importance. If the period of fermentation is too short, the tea will exhibit a raw or bitter flavour. The flavour may be entirely lost if the fermentation process is excessive. Only an expert can decide, by appearance and smell, when oxidation or fermentation is complete. The leaves are next heated and rolled, after which they are exposed to the sun's rays. A second and third roasting and rolling follow, the tea being then ready for sifting, drying and packing.

Tea is usually packed in a warm condition, being placed in lead-lined chests with soldered lead covers so that it remains airtight until required for use. There are various grades or qualities of tea, including grades with broken leaves, the latter type being sometimes objected to by the consumer. Expert opinion, however, holds that the more the leaf is broken the better is the tea liquor after infusion. The top bud and first leaf of the tea plant form what is known as Orange Pekoe tea, the next leaf is known as Pekoe, and the succeeding leaf as Suchong. The remainder of the leaves are too coarse for high-class tea production. The tannin content of green tea is approximately 50 per cent. greater than that of the black variety.

Tea leaves contain a certain quantity of moisture, usually less than 10 per cent., with a high nitrogenous content, amounting to approximately 24 per cent. Tannin (15 per cent.), pectin and fibrin are also present in varying proportions together with gum, fat, essential oils and caffeine. The characteristic qualities, strength and flavour of tea when infused are due to caffeine, tannin and the essential oils, which are mainly concerned with flavour. The commercial value of tea depends mostly upon the essential oils and the aroma. As already indicated, green tea has a higher tannin content than the black variety but contains less moisture, due to the harder fibre produced in manufacture. A high moisture content is an indication of poor condition. Tea will readily absorb moisture if stored under unsuitable conditions. Tea which is in a damp condition when imported is normally rejected at the port of entry.

Storage is important, as tea will absorb the flavours of strong-smelling substances such as paraffin, onions or soap, with which it may come into close contact. Caffeine is closely allied to theobromine, the alkaloid of cocoa, and to uric acid. It acts as a stimulant and is poisonous in large quantities. Indian and Ceylon teas contain the greatest percentage of caffeine ; Chinese and Japanese varieties contain least. Excessive tannin impairs the digestive processes ; prolonged infusion increases the quantity extracted from the leaves. The essential oil contained in tea is lighter than water and possesses a distinctive odour of tea. The ash content averages 5·7 per cent. If 8 per cent. ash is present, this is regarded as proof of adulteration. China tea is sometimes prescribed for health reasons, probably due to the fact that its inferior strength when infused reduces any risk which might follow its improper use. On the other hand, the stimulating and comforting effects normally obtained from tea are considerably reduced with the China variety. To the average tea drinker in this country China tea is insipid, being finer and less bitter. It has never achieved the popularity associated with Ceylon or Indian varieties, which are stronger and more bitter to the palate. Tea sold in Great Britain is almost invariable blended. This facilitates standardised quality and flavour.

Tea is rarely adulterated nowadays, although the addition of foreign leaves, such as slow, willow or elder, has been met with in the past. Tea-leaves dried after infusion have been added, while samples may contain an undue proportion of stalk. Adulteration with *Stachytarpheta jamaicensis*, sometimes sold as Brazilian tea, may occur. This can be detected by a strong violet fluorescence in ultra-violet light. Sand, iron filings, gum and rice have also been used as adulterants, while colouring matters were once used to improve the appearance of the green variety. Such additions are now prohibited. The *chemical examination* of tea is mainly directed towards ascertaining that no foreign leaves have been added and that the total ash content is within normal limits. The percentages of caffeine, lead dust and stalk present are also estimated. Attention has been drawn by the Ministry of Health to the importance of tea imported in lead-lined chests. Analyses of samples have revealed quantities of lead dust varying from 10 to 20 parts per million in dry tea, one-third of which goes into solution or suspension when the tea is infused. A reduction can be brought about by the use of aluminium foil or stout paper linings in tea-chests, although 2 parts per million appears to be unavoidable.

Coffee

Coffee is now being consumed in increasing quantities in this country because of the rationing of tea. Coffee is produced from coffee beans, which are the seeds of the coffee berry. The berries are collected, the seeds being removed and dried. The thin membrane covering the beans is also removed, leaving the smooth beans, which have a waxy appearance. The beans are obtained in two ways. When the original *dry method* is employed, the berries are stripped from the tree in all stages of maturity and are spread out on open drying grounds of cement or brick, being turned daily. The drying process occupies three weeks. Wetting, fermentation or overheating must be carefully avoided. When dry, the husks are removed by threshing. The *wet method*, which is now more common, necessitates separation of the ripe and unripe berries by immersion in water. The unripe berries float on the surface of the liquid and are removed by skimming. After a period of soaking in water the beans are fed to pulping machines. The pulped berries are then allowed to ferment in tanks filled with water. This process breaks down the saccharine substances and loosens the slimy inner part of the pulp, which is removed by further washing. The beans are next machine dried, the parchment being easily removed by special machinery using frictional methods, after which the coffee is cleaned and graded according to the size and quality of the beans. The quality of the beans largely depends upon the soil in which the plant grows and upon climatic conditions.

Before it can be used as a beverage, coffee has to be subjected to the *roasting process*. This distends the beans and changes their colour to dark brown or near-black, depending upon the temperature employed. During the process coffee acquires its characteristic flavour and odour. Coffee roasting is now an industrial process, special types of machinery using various forms of heat being employed. The green odourless beans are transformed into crisp, brittle particles with the characteristic colour, flavour and odour of coffee. The standard of roasting depends upon the preference of the consumer, different countries favouring different roastings. The roasting process is often preceded by the blending of different types of coffee beans in order to secure the aroma, flavour and colouring matter which a particular section of the community prefer. Roasting equipment is highly-specialised machinery fitted with automatic heat-control and timing devices. Different temperatures are employed, ranging from 392° F. to 482° F. Temperatures not exceeding 450° F. are most satisfactory. Approximately 90 per cent. of the original moisture content is removed during roasting ; the sugar is caramelised and, because of the destructive distillation which takes place, between 80 and 90 per cent. of the crude fibre is lost. A slight reduction in caffeine, ash and fat percentages occurs. The nitrogenous content is slightly increased although there is considerable loss in the actual weight of the coffee.

The roasted beans are usually subjected to a *grinding* process before being packaged for sale, although the best coffee is prepared from beans freshly roasted and ground immediately prior to use. Ground coffee undergoes some loss of flavour, while staleness may develop if it is exposed to the air for any length of time. These changes become noticeable after three or four days. Coffee in the bean changes more slowly. To preserve the aroma the roasted berries are sometimes oiled with fat or coated with sugar solution. Resin, shellac and petroleum have also been used for glazing purposes. Oiling and coating are recognised trade practices, but the weight of the coffee should not be increased more than 1 per cent. by this operation. To prevent staleness and loss of flavour developing when ground, the coffee is often vacuum-packed in hermetically-sealed cans. When such cans are opened, however, staleness will gradually develop due to reaction with the oxygen in the atmosphere. For this reason small quantities of coffee should be purchased at one time.

The *composition* of coffee depends upon the place of production, the type of bean and the method of roasting, all of which are variable factors. The caffeine content, which averages 1·2 per cent., often shows considerable variation, up to 2·5 per cent. having been reported. Coffee beans may be extracted with ethyl acetate, yielding a product which contains only a very small quantity of caffeine. The importance of coffee as a beverage is due to its high caffeine content. Caffeine possesses highly stimulating properties. The minerals in coffee consist largely of potassium carbonate and phosphate, although in Mocha coffee, calcium and magnesium salts are also found. Considerable quantities of oily substances are present, consisting chiefly of olein, palmitin and stearin. The aroma and flavour are said to be due to the presence of the oily volatile substances, caffeol and caffeone. The richness of the berries in relation to their oleaginous content can be increased by prolonged storage. The aroma can be increased by the same means, resulting in a blander and more mellow beverage. Whilst coffee berries lose weight during storage, this loss is amply compensated by improvement in quality.

Various methods of adulterating coffee have been employed, *chicory* being the most common substance used for this purpose. Chicory is prepared from the root of a plant of the dandelion species grown in this country and on the Continent. The tubers are dried, roasted and ground and take on the appearance of coffee. If a mixture of coffee and chicory is thrown into water, the chicory will sink and discolour the liquid, whereas coffee will float on the surface and retain its colouring matter. Microscopical examinations can be used to differentiate the two substances. Coffee to which chicory has been added can be sold, but a statement notifying such addition must be clearly set out on the label of the container. Coffee mixtures should contain at least 5 per cent. by weight of pure coffee. Various other substances have been employed to adulterate coffee, among which may be instanced ground beans, maize, corn, peas, acorns, carrots, parsnips, date stones and burnt sugar. *Chemical examinations* are mainly carried out with a view to estimating the caffeine, boric acid, chicory, foreign adulterants, starch and moisture content.

Coffee is mainly produced in Brazil, the West Indies, Central America, Africa, Arabia, India and the East Indies. The United States of America is the greatest coffee-drinking nation, consuming half the total quantity annually produced. Most countries prefer coffee in its pure state. In this country and on the Continent a mixture of coffee and chicory is preferred. It should be noted that chicory has none of the stimulant properties associated with coffee. Coffee exerts a stimulating influence upon the nervous and muscular systems, producing a feeling of buoyancy and exhilaration. The pulse rate is increased, energy being sustained after prolonged muscular exertion. It need scarcely be emphasised that these effects are less noticeable in habitual coffee drinkers. The action of coffee depends mainly upon the caffeine which it contains, although it should be remembered that certain types of coffee contain very little caffeine.

Coffee Extracts

Large quantities of coffee extracts or essences are sold annually in this country in bottled or powdered form. In their production, ground coffee is extracted with boiling water, the liquid being evaporated to low bulk of great strength. Sediment is often found at the base of each bottle. This consists chiefly of caffeine tannate, which is insoluble in cold water but is readily soluble in boiling water. Such extracts may be deficient in caffeine although they should contain not less than 0·5 per cent. weight in volume of caffeine derived from coffee ; adulterations with chicory extracts and solutions of treacle or caramel have been found. Liquid coffee and chicory essence should contain not less than 0·25 per cent. weight in volume of caffeine derived from coffee. No vegetable extracts other than those obtained from coffee or chicory should be used in such essences. Benzoic acid, up to a maximum of 450 parts per million, is allowed as a preservative, but any such addition must be clearly stated on the label. This type of preservative is rarely used, although salicylic acid has occasionally been added for preservative purposes.

Cocoa

Cocoa is produced from the cocoa bean, which is the fruit of the cacao tree. The cacao tree is found in Central America, the West Indies, Africa, Ceylon and the East Indies. The beans or seeds are covered with a slimy pulp contained in pods, which are picked when ripe. They are freed from the pulp by means of a fermentation process, the germ of the bean being destroyed by the heat evolved. A temperature of between 104° F. and 122° F. is allowed to develop during fermentation. This heat stimulates enzymic action and destroys the germ, thus preventing subsequent germination of the seed and reducing bitterness. Excessive temperatures during fermentation must be avoided, as the enzymes would otherwise be destroyed. The enzymes are important. They bring about changes in the composition of the bean, the astringent taste due to the presence of tannin being reduced and the colour and characteristic aroma developed. Alcoholic fermentation occurs first, being followed by acetic acid fermentation. During fermentation the beans lose a proportion of their weight. For this reason there is a tendency to shorten the fermentation process. Fermentation should continue until the beans have lost their vinegary odour but should cease before unpleasant flavours and odours are produced. This period varies from one to twelve days according to the type of bean, the pale-coloured varieties requiring less time than the deep purple and bitter varieties. Following fermentation the beans may be washed. They are then dried in the sun or in ovens and are subsequently roasted. This renders the shell brittle and facilitates removal of the kernel by machinery.

Flavour and aroma are developed during the roasting process, while the colour darkens. Heating destroys any eggs or larvæ of the cacao moth which may be present. The moisture content is greatly reduced. The beans are sometimes polished to impart a brighter appearance, this process also removes any traces of mildew which may be present. They are then packed into bags ready for shipment. Cocoa as it is drunk consists of the cocoa nibs, from which a portion of the fat has been extracted by pressure between hot rollers. Natural cocoa would be objectionable owing to its high fat content. This is usually removed by hot pressing. The fat exuded during the pressing process is yellowish-white. It solidifies and becomes pure white on storage. This fat is used in the manufacture of pharmaceutical preparations and is a constituent of many types of pomades, keeping for long periods without rancidity if carefully stored. The resultant mass is next ground to a fine powder, which is ready for use. Starch and sugar are sometimes added as diluents. Such additions are permitted if the fact that these substances have been added is clearly stated on the label. Exposure of cocoa to the sun causes loss of colour and flavour.

Several varieties of cocoa are manufactured, each of which must possess a minimum cocoa butter content of 20 per cent. and a maximum shell content of 5 per cent. Apart from ordinary cocoa, which contains fat, protein, starch and tannin, drinking chocolate is also produced, consisting of cocoa, sugar, milk powder and flavouring materials. This has a reasonably high fat content. Other varieties include cocoa sweetened with sugar or dextrose and cocoa to which both sugar or dextrose and powdered milk have been added. The fat content, which amounts to as much as 50 per cent. of the whole, contains the glycerides of stearic, palmitic, lauric and arachidic acids. This mixture forms cocoa butter, which is used in the manufacture of confectionery and pharmaceutical preparations. Theobromine, the stimulating principal of both cocoa and chocolate, is present in quantities varying from 1 to 2·5 per cent. The brown colour of cocoa is due to oxidation of the tannins present. The husk is not now included with cocoa powder, as it tends to render the substance bitter. Adulteration by the addition of the ground husk of other nuts has been practised, but rarely occurs to-day. Cocoa for table use may contain a minute amount of ammonia, lime, or sodium or potassium carbonates. This added alkali emulsifies the fat and decreases the tendency of the fat globules to separate. A preparation of this type is termed " soluble cocoa."

Cocoa has a similar action to tea or coffee, the physiological properties of all three being due to the alkaloids and volatile oils which they contain. Cocoa contains theobromine, as opposed to caffeine in tea or coffee. Whereas only an infusion of tea or coffee is drunk, particles of the original substance are in suspension throughout the cocoa when this is consumed. The nutritive value is therefore high. The *chemical examination* of cocoa is mainly concerned with an estimation of the fat, starch and theobromine contents. Cocoa may also be analysed for its protein and sugar content and for the presence of preservatives. Arsenic emanating from the use of contaminated potassium carbonate has also been found.

Non-alcoholic Beverages

Non-alcoholic beverages, or " soft drinks " as they are often termed, are popular, particularly with children. They comprise a variety of liquids, including natural fruit juices, mineral waters of both the natural and artificial type, together with various artificial drinks, usually a combination of citric and tartaric acids, sugars and flavouring and colouring matters. The natural fruit juices are most often of the " still " variety. The remainder are aerated with carbon dioxide. Most of the still varieties are sold in concentrated form, e.g. orange, lemon and grapefruit squashes, and are consumed after dilution with water. Further consideration is given to these substances on p. 284.

Aerated waters, which consist of flavoured water charged with carbonic acid, are popular summer-time drinks. The requisite flavouring and sugar are added to the water, carbonic acid gas at a pressure between 100 and 200 lb. per square inch being injected into the liquid as it is filled by machinery into bottles. These bottles are afterwards closed automatically, usually by means of crown corks. One of the principal ingredients of this type of drink is the *flavouring syrup*. This supplies the flavour, the colour and whatever food value the product contains—usually very little. All syrup contains sugar and flavouring materials, which may be derived from fresh fruit or may be synthetic. Citric acid is a common constituent of syrup, while the sugar content is largely sucrose or corn sugar. When compounded the syrup is often heat treated. It is not always sterile, however, although the sugar content is usually sufficient to restrain bacterial growth and prevent spoilage. Bacterial contamination should therefore be prevented during manufacture and storage.

The water used is of the greatest importance. It should be of a high potable standard and be bacteriologically pure. From the chemical standpoint a low total solids content is to be preferred. Clarity is necessary if a clean-looking, sparkling product is to result. The *carbon dioxide* used should also be of adequate purity. With a view to increasing the solubility of the carbon dioxide gas, the water is usually cooled almost to freezing point prior to bottling. The chilled water may be carbonated prior to the actual filling operations. Bottles are filled and capped automatically. Caps should be maintained in a perfectly clean condition before they are used. They should be tight-fitting, otherwise the gas will leak, leaving the contents flat and tasteless. As the carbon dioxide under pressure forms a protection against bacterial development, any loss becomes even more significant.

In the preparation of soda water, sodium bicarbonate in the ratio of 15 grains per pint is added to the water, although the cheaper varieties may consist mainly of carbonated water without any such addition. For genuine soda water, a sodium bicarbonate content of not less than 5 grains per pint is necessary. Various waters derived from mineral springs are also bottled, e.g. Vichy water, while water treated with quinine and known as tonic water is also carbonated and bottled for sale. Tonic water must contain not less than half a grain of quinine per pint and a statement to this effect must appear on the label of the container. Sugar substitutes such as saccharine or dulcin are occasionally used for sweetening purposes, particularly in the case of the cheaper varieties of aerated waters.

Aerated waters may become contaminated from an impure water supply, sour flavouring matters, impure carbon dioxide or by metallic agents. Dirty bottles and caps represent another possible source of contamination.

Aerated or carbonated waters store well owing to the inhibitory action of the contained acid on bacteria and moulds. When present, yeasts produce changes in flavour together with turbidity and sediment. Strict sanitary control throughout production must therefore be exercised. The bottles should be thoroughly sterilised before use. Careful laboratory supervision of materials and processing, together with medical supervision of personnel, is important. If certain flavouring oils are present in the liquid, exposure to direct sunlight will cause the flavour to deteriorate. Storage at low temperatures away from direct sunlight is therefore advisable. Soda water must not contain any preservative, although cordials and fruit juices of the still variety may contain up to 350 parts per million of sulphur dioxide or 600 parts per million benzoic acid. Brewed ginger beer may contain up to 120 parts benzoic acid per million ; sweetened mineral waters can include up to 70 parts sulphur dioxide or 120 parts benzoic acid per million. Chemical examinations for total solids, ash, acidity, sugars and preservatives are usually made.

Beer and Stout

Beer is obtained by a process of alcoholic fermentation from malted barley, hops and water. At present, however, the strength of British beer, with certain exceptions, has been considerably reduced. A number of other substances may be employed in production. Thus, glucose and invert sugar can be used in place of malt, while vegetable bitters of various types, including quassia, may be substituted for hops. Good beer is still being brewed, but extended war-time restrictions have reduced its gravity in many cases. The best known types of beers or ales—the names are almost universally interchangeable—are *pale and bitter ales*, produced from pale malt and an excess of hops or other substances, and *mild ales*, which are sweeter and contain less bitter material but more alcohol. Yet another type is *porter*, which is coloured and flavoured with roasted malt ; and *stout*, which is a stronger variety of porter. *Lager beer*, which is of Continental origin, is also brewed in this country. Lager beer contains less alcohol but more extractive, and is subject to secondary fermentation unless stored at low temperatures.

The ingredients used in the brewing of beer are of considerable importance. A satisfactory supply of *water* is essential. If the water is contaminated with organic matter it cannot be used for brewing, since it will then produce an abnormal flavour, cloudiness and unsatisfactory fermentation. Some types of water may be suitable for the production of one type of beer but not for another. Dark ales require a soft water, bitter ales a hard water. Water containing sodium chloride is necessary in the production of mild ales. The presence of certain mineral substances in beer after production is not important *per se*, although they do exert an influence upon the solvent action of the water and on the malt and hops. As an instance, good bitter beers cannot be brewed unless the water contains calcium and magnesium salts.

Malt, which should be of the highest quality, is prepared from moistened barley which is stored in a warm place until germination begins. Diastase is developed during this process. The diastase acts upon the starch in the grain and converts a portion into sugar. Further germination is arrested by drying the barley over a kiln. This converts the barley into malt. Good beer should contain no substitutes for malt, although such substitutes may be used in brewing, since operations can thereby be expedited. These substitutes consist of maize and rice from which the oil, moisture and other subsidiary constituents have been removed.

Various types of *sugar* are employed. These include cane sugar, used for heavy mild ales and stouts, and glucose and invert sugar, prepared by the action of acid or yeast on starches and cane sugar. Pure acid should be used for this purpose, as the commercial brand may contain an appreciable quantity of arsenic. This danger is exemplified by an outbreak of arsenical poisoning which occurred in 1900–1 amongst beer drinkers in Lancashire, Cheshire and Staffordshire, 6,000 persons being affected, of whom seventy died. Arsenic may also be present in beer due to the use of arsenical fuel for drying the malt and hops.

Hops are normally responsible for the bitterness present in beer, although substitutes such as quassia, gentian or camomile may be used. These substances are harmless but will impart an unduly bitter taste to the liquid. *Preservatives* are widely employed for draught ales, present-day beer being less stable than its predecessors and subject to more rapid deterioration. Sulphur dioxide is permitted as a preservative in the ratio of 70 parts per million.

A number of different processes are employed in *manufacture*. A gravitation system usually operates throughout the brewery. The malt passes from storage bins through a cleaning and grading apparatus to a *grinding* mill of the smooth-roller type, the material being thoroughly crushed. Grinding of too fine a character will prevent drainage in the mash-tun and subsequent clarification ; if the grinding is too coarse, extraction of the soluble matter will be incomplete. An inadequate yield will then result. The *mashing process* consists of the extraction by means of warm water of the soluble matters in the malt, and the conversion of soluble starch and much of the insoluble nitrogenous compounds into soluble and partly fermentable products, including sugars and maltose. Mashing is the most important part of the brewing process. During this operation the character of the beer is largely fixed. The malt and water are introduced into the mash-tun by means of a mashing machine. A thorough mixing of the grist, as the crushed malt is termed, and the water takes place. The mash-tun is provided with a false bottom composed of perforated plates. These plates facilitate proper separation of the " wort "—the liquid portion of the finished mash—from the spent grains. Stirring apparatus is provided together with an automatic sprinkler, which washes the wort remaining in the grains. When the mash becomes thoroughly homogenous as the result of agitation, it is allowed to rest for a period of approximately two hours, after which the liquid is withdrawn. Two or three barrels of water are used to each 336 lb. of malt.

The quality and type of beer depends almost entirely upon the variety of malt employed and upon the mashing temperature, the entire science of brewing being based upon a suitable combination of these two factors. The range of temperatures employed varies from 140° F. to 160° F., according to the type of beer. High temperatures will destroy the diastase, which converts the insoluble starch into soluble dextrin, sugar and other products. The higher the mashing temperature the greater is the action of the diastase interfered with, more dextrinous or non-fermentable matter, as opposed to maltose or fermentable sugar, being formed. Pale ale should contain a fairly high proportion of dextrose but not much maltose, the opposite being the case in the production of mild ale for quick sale. When starchy matters are substituted for malt, they are usually gelatines, the mass being mixed with the main mash shortly before it is withdrawn from the tun.

The filter-press process may also be used. The malt is finely ground. After mashing, the clear wort is separated from the solid matter in the filter press. By this means an increased yield is obtained. The wort then passes to storage vessels from which it is pumped to a form of copper, where *boiling* takes place, sometimes under slight pressure. When the liquid boils, hops are added. Boiling is allowed to continue for two to three hours. This process concentrates and sterilises the wort, extracts from the hops the substances which give the beer its aroma and flavour and causes part of the coagulable albuminoids to be coagulated and precipitated. Hops, when boiling, give up hop tannin. This assists in precipitation of the malt proteins, the hop resin, which acts as a preservative and a bitter principle, and the hop oil, which provides the aroma. The quantity of hops used varies from 3 to 15 lb. per 336 lb. of malt, according to the type of beer.

Cooling follows, the wort passing to a container known as a " hop back." Here it is allowed time to settle, the liquid being eventually run to a cooler which contains water-cooled and refrigerated sections. Quick cooling prevents bacterial and yeast infection, although contamination may occur with open-surface coolers. The wort is converted into beer by the process of *fermentation*, the action of living yeast cells splitting the sugar contained in the wort into alcohol and carbonic acid. *Top fermentation* with a high temperature and for a short period is usually employed in this country ; *bottom fermentation* is used in the production of lager beer, a longer period at a lower temperature being the rule. Yeast is added to the liquid. After a few hours a scum or froth appears on the surface. The froth increases in extent and solidarity and eventually sinks into a compact mass which emits gas bubbles with a hissing sound. At this point *cleansing* of the beer or the separation of the yeast from the liquid is carried out, various methods being employed. Owing to the rise in temperature which occurs during the fermentation process in the fermenting vats, a tubular water-cooling apparatus may be fitted. This passes through the vat so that the temperature of the liquid may be reduced. After fermentation and cleansing, *racking* takes place, the beer being racked or drawn off into storage vessels or barrels. Various storage periods are required according to the type of beer, pale ales being stored for a longer period than the mild variety. In the case of the better-quality beers additional hops are often added to the casks. Beers which have to become conditioned quickly are primed by the addition of a small quantity of sugar solution, which causes rapid fermentation.

In order to obtain speedy brightening, artificial means of *fining* are often practised. Finings generally consist of a solution of isinglass in sour beer, or a solution of tartaric or sulphurous acid. Irish moss is also used ; gelatine is of little value as a fining agent. Preparations of quillaia, cortex, flavouring essences, saccharine and dulcin are prohibited. Fining assists in removing any turbidity from the beer. Whilst in certain cases special beer is brewed for *bottling*, this is not generally the case to-day. If beer is to be bottled when ripe for racking, it is often cooled to a low temperature. This causes much of the matter in suspension, which would normally settle after storage, to be quickly deposited. The beer is then filtered and rendered bright, after which it is carbonated or impregnated with carbon dioxide under pressure. *Stout and porter* are produced in much the same manner as beer, except that the malt is first roasted. The roasted malt gives these beverages their dark colour.

Cleanliness at all stages of processing is most important. Bottles must be properly washed, and most breweries use modern bottle-washing machines. The detergent strength of the washing solutions must be maintained at all times and correct washing temperatures strictly observed. Bottle washing represents a weak link in the chain of distribution and demands constant attention. The cleansing of stoppers presents a difficult problem, although the increasing use of crown corks has helped considerably. The health of the employees should be satisfactory and must never be overlooked.

The *composition* of beer varies considerably. Alcohol is a prime constituent of which from 3 to 6 per cent. may be present, together with 4 to 7 per cent. of solid matter. The solid matter consists mainly of maltose or malt sugar, several types of dextrin and non-coagulable proteins and peptones. An appreciable quantity of mineral matter is also present, chiefly phosphates and potash. Good beer has considerable *food value*, the nutriment which it contains being present in a ready assimilable form.

Control is mainly concerned with *chemical examination*, including adulteration with water. This is a revenue offence. Tests are also made for excess or undesirable preservatives, e.g. salicylic or boric acids. Chemical examination further indicates an estimation of the total solids, ash or sodium chloride content, acidity, bitter substances content, the presence of prohibited materials used for fining and arsenic. A limit of 1/100th grain of arsenious oxide per gallon has been fixed. Improved methods of production and control are at present indicated. The use of lead piping through which the beer is drawn from barrels in the cellar to pumps on the counter and the use of lead- or enamel-lined vats or tanks represents a health hazard. Cases of lead poisoning have occurred following dissolution of these materials in beer. In 1922, ninety-three cases with one death occurred in Middlesex due to the consumption of beer stored in enamel-lined tanks. Up to 1·9 grammes per gallon of lead were found in the liquid. Chronic lead poisoning due to beer was reported in 1936 from a London borough. The beer, which contained 1 part per million of lead, had been drawn from the barrels through old lead pipes. Samples of beer obtained by food and drugs authorities are frequently found to contain lead in solution, often to an excessive degree. Either glass or plastic tubing or blocked tin or stainless metal pipes should always be used for delivery to the counter. While no danger of poisoning from such materials exists, their thorough cleanliness at all times is essential. When blocked tin pipes are used, the coating of tin should be adequate and should not be damaged or worn in any way.

Cider

Cider is produced by the fermentation of the juice expressed from the pulp of apples and has an alcohol content varying from 3 to 8 per cent. So far as this country is concerned, cider is principally manufactured in the south-western counties, Norfolk and, to a limited extent, Kent. It is also produced abroad. The apples used in production are of a special type, being solely grown for the purpose of cider making. *Manufacture* is a reasonably simple matter. When produced on the farm, the cider apples are ground, the ground apple pulp, or pomace, being built into " cheeses." These are pressed in a hand press to extract the juice, which is stored in old wine barrels. The juice is racked after a short storage period, necessary for fermentation purposes. Both " sweet " and " rough " varieties of cider are manufactured. Farm-house cider is usually of the " rough " or bitter type, the bitterness increasing during storage. Cider making is now generally carried out in factories, the same processes being employed. Power-driven machinery is used, particularly for grinding the apples and pressing the pomace, which is placed in layers or " cheeses " separated by straw or wooden slats. A pressure of several tons is often applied to extract the maximum quantity of juice. After extraction, the pomace is occasionally broken up and re-pressed, although the liquid so obtained cannot be manufactured into first-class cider.

Several varieties of apples may be used to obtain the required blend of cider, since it is rare to find the qualities of richness, flavour and astringency in one type of apple. During the fermentation process the saccharine ingredients are inverted into alcohol and carbonic acid gas. *Fining* of the cider is sometimes carried out to clear the juice and to facilitate its passage through the filters. These are usually composed of layers of compressed cotton or other filtering materials, through which the liquid is forced. Heating to a temperature of 165° F. is occasionally practised. This coagulates the soluble proteins and facilitates subsequent clarification. *Filtration* is essential to the bottled cider trade, where a clean sparkling drink is required.

Cider is sometimes pasteurised by the " flash " process at a temperature of 180° F. to prevent deterioration. Care must be taken to ensure that a cooked flavour does not develop. Bottled ciders are usually carbonated, the carbon dioxide gas improving the flavour and imparting the desired sparkle. Draught cider is generally a cloudy liquid. Fining is carried out by the use of materials of an albuminous nature, such as skimmed milk whipped to a froth and gradually blended with the cider as it is pumped into the mixing vat. The quantity of fining materials used should be reduced to a minimum. The increasing demand for bottled cider has resulted in various refinements, mostly concerned with clarification of the juice. A combination of gelatine and tannin has been employed for the precipitation of the suspended colloidal material prior to filtration ; enzyme preparations, which attack the contained pectin and starch, frequently the cause of cloudy appearance, have been used for the same purpose. Various types of preservatives are used, as cider quickly sours and will not keep for lengthy periods unless bacteria and yeasts are inactivated. Salicylic and boric acids, together with formalin, were formerly used as preservatives. Their use has now been prohibited, only sulphur dioxide in the ratio of 200 parts per million being permitted.

If cider were always properly filtered and if appliances and containers were maintained in a scrupulously clean condition at all times, the use of any form of preservative would be obviated. The cleanliness of bottles used as containers is also important. Bottled cider is often stored for long periods before use, its condition deteriorating rapidly when dirty bottles are employed. Too many unsound apples are still being used in cider making, while earthy material is not always removed from the apples. Excessive uncontrolled fermentation often takes place.

Perry, made from the fermented juice of pears, is produced in a manner similar to cider. With both processes constant cleanliness is important in all stages of manufacture. Only good sound fruit should be used if the final article is to be of the highest quality.

Pure unadulterated cider and perry have long been recommended by the medical profession as an efficacious remedy in cases of gout or rheumatism. Rough cider is also stated to prevent diarrhœa, colic and similar complaints. The alcohol and sugar contents of cider and perry have a certain nutritive value, while the beverages act as appetisers. *Chemical control* is mainly concerned with the acidity, phosphate or potash content, and with the quantity of preservatives present. Both cider and perry are acid liquids and can therefore exert a solvent action upon lead. Because of this property, they have occasionally given rise to lead poisoning. As long ago as the sixteenth century it was noted that the lead glaze of earthenware vessels was dissolved by cider, this glaze being compounded of lead oxide. An outbreak of lead colic, traced to cider drawn through tin-washed lead pipes from barrels to the counter, was reported from Devonshire in 1932. Between 1/10th and 1/20th grain of lead per gallon was found in the liquid.

Spirits

When substances such as wheat, maize and barley are fermented they produce alcoholic liquids. These liquids, when distilled, yield a spirit. The strength of the distillate is expressed in terms of proof spirit. The alcoholic strength of spirits is normally expressed as over proof or under proof, according to the percentage of alcohol contained. Spirits must not be more than 35 degrees under proof. The spirits commonly consumed in this country contain ethyl alcohol and water. They may also contain other alcohols, various compound ethers and aromatic bodies. These latter substances are responsible for their characteristic aroma and flavour.

When supplies permit, the type of spirit consumed in greatest quantity in these islands is *whisky*. Whisky is produced in Scotland and Ireland, the Scotch variety, which has a dry, clean flavour, being generally in greater demand. The American varieties of rye and bourbon whisky also have a limited sale in this country. Owing to the prevailing shortage, some types of Continental whiskies are now imported, but cannot compare with the local varieties.

Scotch malt whisky is distilled in a *pot still*, malted barley, which has been carefully dried being used. It is usually a heavy whisky with a full flavour. The characteristic flavour of certain varieties of Scotch whisky is said to be derived from the smoke of peat or a mixture of coke and peat used for drying the malt. The type of barley employed, the quantity of peat used in curing the malt, the quality of the water, the method of distillation and the size and shape of the still also affect the flavour. After drying, the malt is made into a mash with water, mash-tuns on the lines of those used in breweries being employed. The material is then allowed to ferment. In order to obtain maximum yield four separate mashes are made from the same batch of grist, the temperature of each succeeding mash being higher than its predecessor. The liquors obtained from the first three mashes are mixed, while that from the last mash is used for the succeeding batch of malt. Fermentation takes place at temperatures between 70° F. and 90° F., a small quantity of yeast being added to start the process. Distillation of the fermented mash or " wash " then takes place, a pot still heated by an open fire or steam coils being used. The still, which may hold between 3,000 and 8,000 gallons, is constructed of copper. As distillation takes place in a single worm cooled by running water, the spirit is not separated from the by-products of fermentation. Agitation is provided to prevent the solid materials in the " wash " becoming charred. The distillate obtained is generally 50 degrees under proof and is termed " low wines." This liquid is re-distilled in a smaller but similar type of vessel, the final strength of the whisky being 25 to 30 degrees over proof. The object of double distillation is to concentrate and rectify the alcohol. Newly-distilled whisky produced by this process is raw and fiery and is stored in wooden casks for several years in order that it may mellow and mature.

Irish pot-still whisky is manufactured in a similar manner from a mixture of malted barley and unmalted barley, rye or maize. The malt is usually kiln dried. The process of distillation differs from that used in the production of Scotch whisky, the final product acquiring a round sweet flavour. The stills used are much larger than in the Scotch type, holding up to 20,000 gallons. Three stills are normally employed. *Scotch grain whisky*, which is lighter in flavour and body, is produced from a mixture of barley, rye and maize, with the minimum quantity of malt required to convert the starch of the various grains into sugar. Steam distillation in a *patent still* is employed, the apparatus being designed in such a way that the by-products of fermentation are mostly separated from the ethyl alcohol. This type of whisky does not require lengthy storage before being consumed. *American whisky* is manufactured either from rye or from maize. Both varieties exhibit a higher flavour and greater body than do either Irish or Scotch whiskies. They are invariably stored in heavily-charred barrels ; the period of maturity is much longer than that pertaining to whiskies produced in this country.

Whisky is colourless when distilled, the characteristic yellow colour being acquired from storage in sherry casks, from which it takes up traces of sugar and tannin, or by the addition of caramel. Apart from the nature of the casks employed, the maturing of whisky is influenced by the atmospheric condition of the cellar in which the spirit is stored. Many commercial whiskies are the product of careful scientific blending of malt and grain types. Ten or even more varieties are mixed together when whisky is vatted. After reaching maturity, several vats of mixed whisky are blended to produce the final blend. The alcohol content of average whisky varies between 40 and 50 per cent. It usually contains a trace of free acetic acid, rarely exceeding 0·1 per cent. The total solids are seldom greater than 0·15 per cent.

Whisky exerts a rapid stimulative effect upon the human body, except with habitual whisky drinkers. Use can be made of this stimulative action in the treatment of shock. There is later a delayed depressant action, which may be dangerous. The signs and symptoms of acute and chronic alcoholic poisoning belong to a text-book of medicine and need not be dealt with here. It may be shortly stated, however, that whisky is normally drunk for pleasure because of the feeling of well-being, sometimes exhilaration, which it creates. The taste for whisky, whatever the type, is acquired.

Gin probably ranks next in popularity to whisky. Gin has an alcohol content varying between 50 and 70 per cent. It is a compounded spirit which derives its characteristic flavour from the juniper berry. Two types of gin are procurable, the Dutch type, known as Geneva or " Hollands," and British clear gin. Dutch gin is prepared from malted barley and rye, infused into a mash at high temperature. After cooling, a small quantity of yeast is added to start fermentation, which is carried on for two to three days. The " wash " is then distilled and the resultant liquor re-distilled, a small quantity of juniper oil or coriander flavouring together with salt being added. In some cases the juniper berries are mixed with the wort, the whole being allowed to ferment. Wheat is sometimes used in place of rye, while hops may be added to the final distillate. In the manufacture of British gin a highly-rectified spirit is re-distilled in the presence of juniper and coriander, which provide the characteristic flavour. This operation is frequently repeated a number of times to obtain what is known as "dry" gin. Sugar is sometimes added to provide a sweetened form of spirit. Inferior varieties can be produced by omitting the distillation process and by adding the essential oils to plain rectified spirit. The essential oil of juniper is a powerful diuretic.

Brandy is an alcoholic spirit derived from grape wine. *Manufacture* of the finer brandies is a relatively simple matter. The character of the final product depends upon the original wine, together with selection and blending of the constituent materials. The best brandies are produced in France. A reasonable-quality brandy is manufactured in Spain, while brandies of South African and Australian origin have appeared on the market during recent years. A simple type of pot still is used for *distillation*, although the process becomes more complicated when wines of lesser quality are used, owing to the higher rectification required. Stills are generally small, with an approximate capacity of 100 gallons. The liquor is distilled slowly and carefully, the process lasting some eight hours. The spirit is sometimes collected in one receiver ; alternatively, the first distillation, which may contain between 25 and 35 per cent. alcohol, is divided into several fractions, which are re-distilled. The mixing of several distillations is also practised, the final distilled spirit having an alcohol content of between 66 and 70 per cent. The distilled spirit is colourless and of a fiery character and requires *storage and maturation*. This mellows the final product.

Oak casks are used for storage purposes, the liquid extracting colouring matter and tannin from the containers. After prolonged storage the brandy contains large quantities of aldehydes and volatile ethers, which impart the characteristic flavour. These substances have valuable therapeutic properties. Commercial brandies are usually blends of different growths and vintages, blending being completed in large storage vats some time prior to bottling. In the case of pale brandies very little colouring matter is added, the usual quantity being ½ to 1 per cent. Brown brandies, which are not now popular, require the addition of more caramel and sugar than do the pale varieties. The addition of colouring matter gives commercial brandy a standard colour. Colouring and sweetening matters are added in the vat. The mixed caramel and sugar syrup is known as the "liqueur." Its method of preparation usually remains the secret of the producer. Good-quality "liqueur" is prepared with high-class brandy and is stored for a number of years before use. Brandy improves with keeping provided it is stored in the wood ; little improvement takes place after it is bottled. Brandy does not, however, improve indefinitely, even when properly stored. After a certain period, which varies with the type of brandy and vintage, the alcohol evaporates to such a degree that undesirable changes take place. The brandy then becomes "worn" or "tired." Bottling must not therefore be deferred for too lengthy a period. Brandy is used medicinally to supply energy in a particularly labile form. It can also act as a stimulant, carminative and hypnotic. A number of cheap brandies are composed entirely of spirit distilled from grain, suitably coloured and flavoured. These substitutes have little or no therapeutic value.

Rum, a product of the West Indies, is prepared by the fermentation of the cane-sugar residues, or molasses. It has an alcohol content of between 50 and 60 per cent. Rum falls into two main classes, Jamaica rum and rum produced in Demerara or Trinidad. Two kinds of *Jamaica rum* are produced. The first is *common clear rum*, prepared from sugar-cane molasses, the skimmings or scum from boiling cane juice and spent "lees" from previous distillations. The skimmings are subjected to acid fermentation before being used alone or in conjunction with crushed sugar-cane. The wort, which contains from 10 to 15 per cent. sugar but very little yeast, ferments slowly. Fermentation, which occupies from five to ten days, is mainly alcoholic in the initial stages, but later takes on an acid character, due to the development of acidifying bacteria. Distillation is carried out in pot stills heated by fire or steam. The stills may be of the simple type and may be fitted with rectifiers. When a simple still is used, two distillations are required. Jamaican rum, which is flavoured and is also known as "German" rum, is prepared from similar materials to which are added "acid," obtained from acidifying cane juice, and flavour, prepared from spent "lees." Bacterial fermentation results in the formation of large quantities of acid, including butyric acid and compound esters. Distillation is carried out in the manner already described. Flavoured rum is almost entirely used for blending with the lighter types of spirit. *Demerara rum*, which is fermented largely by bacterial action, is much lighter in flavour. Patent and rectifying stills are used in its production. Rum contains a high percentage of compound esters as compared with whisky or brandy. It has a deep brown colour, imparted by the contained caramel or by storage in sherry casks.

Spirits must not be more than 35 per cent. under proof, the commonest adulterant being water. Notices are often exhibited in public-houses and hotels to the effect that no definite spirit strength is guaranteed. The purposes of such notices is to protect the vendor against action under the Food and Drugs Act, 1938. Notices of this kind are frequently so worded that their real meaning is not understood by the majority of customers. *Chemical examination* mainly deals with the estimation of water, the alcoholic strength, the presence of methyl alcohol and secondary constituents, such as esters, volatile acids and aldehydes.

Wines

Wine is produced from grapes and may be defined as fermented grape juice with additions essential to stability and keeping quality. The character of a particular wine depends upon the nature of the soil on which the grape-vine is grown, climatic conditions and the variety of vine cultivated. Quality depends almost entirely upon the vintage. This is affected in turn by weather conditions preceding and during harvesting of the grapes and by subsequent fermentation. Wine is produced in many parts of the world. Wines produced in Italy, South Africa and Australia have great body and strength, but no wine can be compared with that produced in France or Germany so far as flavour and bouquet are concerned. If grown on different soils, a particular type of vine will produce a different wine in each instance.

When compared with the production of beer and spirits, the *manufacture* of wine is a comparatively simple though more lengthy operation. The mature grapes are collected, the stalks being removed, and pressed either by treading with the feet, in a simple form of hand press or by passing through rollers. When red wine is produced, the skins of the grapes are not removed, as these give colour to the liquid. The expressed juice, known as "must," is then fermented, its sugar being converted into alcohol and various subsidiary products. No yeast is added to the juice, as *fermentation* is spontaneously evoked by the action of the yeast cells present in the skins and in the substance of the grapes. Fermentation is relatively slow at first but increases in intensity, continuing until practically all the sugar has been converted. In certain sweet wines, such as Port or Sauterne, fermentation either stops naturally as the yeast cells cease to act or is stopped artificially by the addition of spirit or by other means. When fermentation has ceased, the wine is transferred to casks or vats. These are kept full by the addition of further quantities of wine. Secondary fermentation then takes place, the carbonic acid gas escaping from the liquid through the bung in the cask. This aperture is provided with a water seal which allows gas to escape but prevents the entrance of air. The wine throws out a deposit which forms a coherent crust known as "argol" or "lees"; this consists mainly of tartaric acid, tartrate of lime, yeast cells and albuminous and colouring matters. This deposition is completed within four to five months. The wine is then more or less bright and receives its first *racking* into clean casks. This separates the bright liquid from the deposit, and is repeated three to four times at intervals of some months. As racking does not produce the desired brilliancy, *fining* is required. Isinglass or gelatine is added to white wines; white of egg is employed for the red variety. These protein substances combine with part of the tannin in the liquid to form an insoluble tannate, which carries the insoluble matters to the bottom of the vat. Those wines which lack tannin are often difficult to fine. Mechanical methods of filtration are employed in such cases.

Great care must be taken to ensure cleanliness of the casks into which the wine is racked or in which it is stored. Sulphur is usually burned in the casks, the sulphurous acid formed destroying any micro-organisms which may be present. Sulphurous acid also reduces the supply of oxygen and renders the liquid less likely to acid fermentations. Sweet wines, which are likely to "fret," are sulphured more frequently than are the dry varieties. When wine has matured sufficiently—the period varies from two to four years—it is ready for bottling. Some wines, e.g. certain types of port, are stored in the wood for a further period of years. Their character is considerably improved by such storage.

The final *composition* of wine depends on the results of the fermentation process. Ethylic alcohol, water and carbonic acid are present, together with subsidiary products such as glycerine, succinic acid and small quantities of the higher alcohols, volatile acids and compound esters. In red wines a certain quantity of colouring matter dissolves from the grape skins, mineral matter and tannin being also extracted from the skins. The alcohol content varies between 7 and 18 per cent.; the acidity, which is reduced during the fermentation process, lies between 0·3 and 1 per cent. The alcohol content of the lighter wines, such as Bordeaux, Rhenish varieties, Burgundies, champagnes and Moselles, is generally between 7 and 15 per cent.; sherry, port and Madeira, the stronger wines, may contain up to 18 per cent. alcohol, and even more in certain instances. The total solids content varies between 1·5 to 3·5 per cent., the mineral content amounting to approximately one-tenth of this total. Red wines contain most tannin, usually from 0·4 to 0·5 per cent. Generally speaking, an increased percentage of volatile acids, e.g. between 0·1 and 0·15 per cent., indicates undesirable or abnormal fermentation.

The bouquet of wine is a product of the compound esters contained in the wine. Sweet wines are sometimes fortified by the addition of brandy ; British wines are fermented from imported grape " must " to which yeast is added. Other additives are water, alcohol, tannin, raisins, glycerine and similar wine constituents. There is no hygienic objection to these varieties of wine, provided they are carefully prepared. They do not, however, possess the delicate qualities and stimulating effects of the natural varieties. To increase dryness and improve the keeping quality of wine " *plastering* " is often resorted to, calcium sulphate being added either to the grapes prior to pressing or to the fermenting " must." This process also assists clarification. The calcium salt is deposited with the " lees," potassium sulphate remaining in solution. This latter salt may be harmful if present in excessive quantities. More than 2 grammes potassium sulphate per litre of wine is prohibited in France and Spain.

Some wines are pasteurised to prolong their life and to impart a flavour otherwise obtained only by age. Many Continental wines are mixed or blended for export purposes, this constituting the commonest form of adulteration. The trade requires a uniform product and, as natural wines vary to some extent from year to year, the process is a recognised trade practice. The use of sulphur dioxide in the ratio of 450 parts per million is permitted as a preservative. Benzoic acid may not be used in alcoholic wines. Many unfermented " wines " are sold. These generally consist of clarified fruit juices with added saccharine and preservatives. Unfermented grape juice and non-alcoholic wines made from such juice may, if properly labelled, contain up to 2,000 parts per million benzoic acid. Other non-alcoholic wines may contain 350 parts per million sulphur dioxide or 600 parts per million benzoic acid. Meat and malt wines should contain approximately 5 per cent. of a mixture of meat and malt extracts, with a wine basis. *Chemical examination* is mainly directed to determining the alcohol, sugar and acid contents, the detection of foreign colouring matter and the addition of preservatives.

Light wines, judiciously selected, can assist digestion. Their food value is negligible.

Liqueurs

Liqueurs are perfumed or flavoured potable spirits sweetened by the addition of sugar. The term is also applied to old brandy or whisky. The main ingredients of a liqueur are a relatively strong pure alcohol or spirit, sugar or syrup and flavouring materials. Three methods of *manufacture* are employed. High-class liqueurs are produced by macerating various aromatic substances, such as seeds, leaves, roots, etc., with strong spirit, the infusion being subsequently distilled in the presence of whole or part of the solid matter. A solution of sugar or syrup is added. Colouring matter is frequently introduced, burnt sugar or vegetable extracts being used for this purpose. Further quantities of flavouring substances such as essential oils may also be added. The second method, generally employed in the production of an inferior or second-quality article, consists of the addition of various essential oils to strong spirit, the mixture being filtered. Sweetening matter is added to the clear filtrate. When the third method, the infusion process, is employed, alcohol and sugar are added to fresh fruit juices. Liqueurs have either a thick oily consistency or are limpid and less sweet. Many liqueurs contain only one flavouring substance or have the prevailing flavour of a particular ingredient ; others are compounded of many aromatic principles. The types of flavouring agents used are usually kept secret, but aniseed, peppermint, citron and mint, together with lemon and orange flavours, are commonly employed.

Fruit Juices

Fruit juices have provided popular and refreshing beverages for many years, either prepared or in their natural state. Within recent years substantial advances have taken place both in quality and attractiveness. As already indicated on p. 272, fruit juices form the basis of various types of cordial and still non-alcoholic beverages, such as fruit squashes. Orange, lemon, grape-fruit and lime juices are being sold in increasing quantities ; more recently, canned grape juice and pineapple juice have made their appearance in this country. Tomato juice is rapidly becoming popular. Apart from their attractive flavours, these fruit juices provide a useful source of vitamin C. Most varieties of fruit juice are packed in glass bottles, although improved methods of canning and the use of acid-resistant enamels for lining metal containers have resulted in increasing quantities being sold in sealed cans. Producers have not been slow to emphasise the quality of the fruit juices for which they are responsible. Such advertising efforts have enhanced the popularity of these juices, resulting in increased consumption. This has been aided by the shortage of fresh fruit which persisted during the war years.

Fruit juices produced on a commercial scale must primarily be palatable. This fact necessitates the use of fruits which have an attractive flavour and aroma. In addition, the liquid must have a pleasing appearance and be popular with the public. All fruit juices do not fulfil these requirements. Fruit juices must contain a reasonable quantity of the natural fruit acids, which impart appealing tartness. They must also be capable of withstanding treatment and storage without losing any of their desirable qualities. The fruit must be picked and treated when the acid and sugar content is at its maximum. Only sound clean fruit can be used, since it is impossible to obtain high-grade juice from an inferior article. Rot, mould, fermentation or dirt in the crushed fruit will result in a poor-quality product. Any spray residues which may be poisonous should be eliminated by careful sorting and washing before processing is carried out. The internal surfaces of the crushing apparatus should be constructed of metal which is resistant to fruit acid in order to prevent colour changes and flavour defects. This is particularly important in the case of citrus fruits. Certain fruits darken or lose their attractive appearance when exposed to the atmosphere even for short periods, while all fruit juices are subject to bacterial spoilage unless properly handled or stored.

Orange juice forms the basis of one of the most popular fruit beverages, commercial products being mostly satisfactory. The production of a high-grade orange juice is difficult. Unless great care is taken, the natural flavour changes rapidly after the juice has been extracted, giving way to stale off-flavours due to enzymic reactions and oxidation in the juice. The oranges are washed to remove surface dirt and are then sorted, partially-decayed or over-ripe fruits being discarded. Fruit which has been subjected to sweating or colouring is also undesirable. Extraction of the juice may be carried out in two ways. The fruit can be crushed. The juice may then contain oil expressed from the skins. Spindling, which is also employed, slowly removes the pulp but does not free the oil from the skin. When the juice and pulp have been obtained, the mass is screened to remove the seeds and the larger particles of pulp. The total acidity of the juice should be approximately 1 per cent. if the flavour is to be satisfactory. Sugar and syrup together with orange oil are sometimes added to improve flavour. The juice is frequently vacuum-processed for de-aeration purposes, as a preservative against oxidation, which will quickly impair its flavour. If lengthy storage is anticipated, the juice may be "flash" pasteurised at 205° F. to prevent subsequent fermentation and to inactivate the enzymes. It is afterwards cooled to between 170° F. and 180° F. before being filled into containers under vacuum.

The bottles or cans are next sealed and cooled to storage temperature. The lower the temperature at which the juice is stored the better will it keep without change of flavour. Orange juice is also concentrated in large quantities under the auspices of the Ministry of Food for use by children. Changes in the juice which cause it to darken are detrimental to the vitamin C content. Conditions likely to produce such changes must therefore be avoided. If salts of tin and certain sulphites are present, oxidative changes are retarded. Bottled orange juice is usually stored at room temperature. Minute quantities of copper or iron salts may obtain entrance from plant or utensils and may impair the flavour; stainless steel or aluminium surfaces do not produce flavour defects. Orange juice sealed under vacuum and packed in airtight containers can also be preserved by freezing. This process does not affect the vitamin C content to any appreciable extent, even after prolonged storage. The yield of juice varies from 90 to 100 gallons per ton of ripe sound fruit.

As in the case of orange juice, *lemon juice* is subject to flavour and colour changes. These call for removal of the maximum quantity of air during processing. The method of preparation is similar to that already discussed in relation to orange juice. Lemon juice is occasionally dried to a powder by means of the spray-drying process, sugar being added to the juice prior to drying. The yield of juice per ton of ripe sound fruit varies from 60 to 70 gallons.

Large quantities of *grape-fruit juice* are either bottled or canned annually. The flavour, even when heat treated, does not differ materially from that of the juice in its raw state. A portion of the pulp is contained in suspension in the extracted juice, which is usually sweetened by the addition of sugar or sugar syrup. The juice is extracted as with oranges, strained, sweetened, processed and cooled. A minimum quantity of the oil contained in the skin must be incorporated, otherwise flavour changes will occur. The fruit is therefore halved, being either reamed or pressed during the extraction process. The seeds and large pieces of pulp are removed by passing the juice through perforated stainless steel or monel metal conical filters provided with beaters, which break down the pulp. Various methods of processing are employed. In some cases the juice is heated in tanks to temperatures between 160° F. and 180° F., run into cans which are sealed and finally pasteurised. Cold juice may be run into cans which are exhausted and afterwards pasteurised; cold juice may also be "flash" pasteurised. In other cases the juice is run into cans which are vacuum-sealed. Pasteurisation again follows. Whichever process is used, the temperature in the centre of the can must reach 170° F. Immediate cooling after processing is essential. Bottled juice is prepared in much the same way, being pasteurised and cooled before bottling takes place. The yield of juice varies from 100 to 110 gallons per ton of ripe sound fruit.

Canned *grape juice* has recently made its appearance in this country. In America grape juice has been popular for many years. The maturity of the fruit exerts a considerable influence on the finished product. As all grapes are subject to rapid deterioration after harvesting, rapid processing must be carried out if bacterial development is to be avoided. The grapes are carefully washed. They are then crushed and stemmed mechanically, crushing being carried out by means of opposed rotating cylinders with corrugated surfaces. The precise treatment depends upon the type of grapes being pressed and upon the variety of juice—red or white—required. To obtain red juice the skins must be heated to extract the colouring pigments. Heating is unnecessary in the case of white grapes, while the de-stemming process may also be omitted in the absence of heat. When heating is employed, temperatures slightly above pasteurisation level are used, the crushed grapes being pressed. A lower yield results if the heating process is omitted. The juice is then filtered, pasteurised and finally cooled, being stored at low temperatures. This precipitates the coagulated proteins and facilitates separation of the argols, the source of tartaric acid, a normal constituent of grape juice. Storage temperatures in the region of freezing point are most satisfactory. Glass-lined containers are usually employed. These are covered to prevent re-contamination of the pasteurised juice. The juice is next filtered and clarified by the addition of organic materials such as casein. The clear product is again heated to 170° F. for thirty minutes and filled into the final containers. Pasteurisation may be carried out when the juice is in the container.

Lime juice has acquired considerable popularity in this country and is a useful anti-scorbutic. Its preparation follows closely on the lines already set down for other fruit juices, and it is a useful source of vitamin C.

Tomato juice has become popular during recent years because of its acceptable taste and high vitamin content. Only the best-quality fruit should be used. Mouldy, over-ripe, partially rotted or green tomatoes should not be employed, as they will result in the production of off-flavours. Bruising and contamination during handling should be carefully avoided. The tomatoes are soaked in cold water to loosen any adherent soil. They are well washed, trimmed, peeled and cored and, after a final inspection, are washed again. Various methods of processing may then be employed. The fruits may be scalded with steam or mechanically crushed before extraction takes place. Various types of continuous pressure extraction methods can be used. In this connection it is important that the introduction of air should be minimised because of the serious effect which this may have upon the vitamin C content. In some cases the juice is homogenised, producing a more stable suspension of the final product. To prevent oxidative changes, air is removed from the juice under vacuum. The juice is handled under reduced pressure until it is finally heated and filled into glass or metal containers, which are then cooled. The paramount qualities of tomato juice are flavour and colour. Metals with which it comes into contact affect the final product. Copper may produce an astringent flavour ; iron and brass also affect the flavour. Glass-lined or stainless steel equipment should be employed to prevent these defects. Spoilage in the juice is usually caused by non-spore-forming organisms. This difficulty can be obviated by care in preparation and handling together with proper heat treatment. Tomato juice may also be concentrated to form a puree, used in the production of soups and sauces.

CHAPTER XIX

CONDIMENTS AND SPICES

Various condiments, such as vinegar, pepper, salt and mustard, form the basis of many types of pickles and sauces, being flavoured with different spices with a view to obtaining the desired flavour.

Vinegar

Vinegar, which is the main constituent of all sauces and pickles, is also commonly used for table purposes. It is a dilute solution of impure acetic acid prepared by the alcoholic and acetous fermentation of a saccharine solution without intermediate distillation. It is also an important preservative which can be used safely for the treatment of a variety of foodstuffs. Two types of vinegar are manufactured : malt or brewed vinegar, derived solely from malted barley, and " artificial " or non-brewed vinegar, which contains acetic acid but is not a product of fermentation. When *malt vinegar* is manufactured, the malt or malt and barley are " mashed " and soaked in successive quantities of hot water until the soluble content of the grain has been removed. The clear liquor, or " wort," is then cooled and transferred to another vat. Yeast is added, alcoholic fermentation taking place, with the evolution of carbon dioxide. The " wash " is pumped over piles of beech twigs, shavings or wicker work placed in tall vats, into which a regulated supply of air is allowed to enter. The twigs become coated with *Mycoderma aceti*, or vinegar plant, which converts the alcohol into acetic acid. The pleasant taste and smell of malt vinegar is due to the small quantities of ethyl acetate and aldehyde formed during the process. A small quantity of alcohol, usually about 6 per cent., remains in the finished product. This improves flavour and keeping quality. Storage for periods from six to twelve months, which allows the flavour to fully develop, are quite common. Improvement in flavour is due to the formation of esters. Storage temperatures should preferably lie between 40° F. and 50° F. Malt vinegar is occasionally pasteurised at a temperature of 145° F. with a view to improving the keeping quality.

Other types of fermented vinegars are produced from grape juice or white wine, the liquid being known as wine vinegar. A type of vinegar can also result from the distillation of wood, wood vinegar being formed. White vinegar is prepared by the distillation of malt vinegar and is used extensively by pickle manufacturers. Spirit vinegar, prepared by the acetous fermentation of dilute alcohol, is also available. *Artificial vinegar* is produced by the dilution of strong acetic acid and is usually coloured with caramel. The acid used in the production of artificial vinegar was formerly obtained by fermentation, but is now for the most part synthetically produced. After production, vinegar is packed in bottles or in barrels. It is a common practice to subject the liquid to filtration and clarification to remove sediment and suspended matter. When packed in glass bottles, pasteurisation after filtration is very often carried out.

Vinegar should contain between 4 and 8 per cent. acetic acid. If the acid content is less than 4 per cent., adulteration should be suspected. Vinegar should contain only acetic acid or those acids produced by the normal fermentation processes. Sulphuric acid may be present in vinegar; 0·1 per cent. should be the maximum. Wine vinegar may have an acetic acid content between 5 and 5·6 per cent., and may contain traces of potassium tartrate. Vinegar is liable to contamination from the apparatus used in its manufacture, copper having been found on a number of occasions. Arsenic may also be present, being derived from arsenical malt, caramel or glucose. Potassium ferrocyanide is sometimes employed for clarification purposes. The acetic acid may act on this substance, producing hydrocyanic acid. The use of such clarification substances should therefore be viewed with grave suspicion. Good vinegar should be clear, bright, dark brown in colour and should have a strong sourish taste and characteristic smell. When the acetic acid content is reduced, the colour is paler, while the liquid has a dull, cloudy appearance. The acid content is lowered during storage, the strength of the vinegar being reduced.

Chemical examination is mainly concerned with (*a*) estimating the acetic acid content, (*b*) distinguishing between the various types of vinegar, and (*c*) detecting the presence of preservatives. These latter are prohibited, although a small quantity of sulphur dioxide may be introduced as an ingredient. Vinegar may become infested with small parasites known as "vinegar eels" (*Anguillula aceti*). These develop in the generators into which the liquid is run after treatment. They can be readily removed by filtration, and are destroyed if the liquid is pasteurised. Vinegar flies occasionally infest the premises in which the liquid is produced. They can be easily controlled by the application of hygienic measures of production or by fumigation. Vinegar mites can be similarly controlled.

Vinegar can be used to bathe the skin in cases of pyrexia, acting as a pleasant refrigerant. The acetic acid which it contains has no internal therapeutic value, although statements have been made that it cures obesity, a belief for which there is no scientific support. The excessive consumption of vinegar may injure the mucous membrane of the stomach and so interfere ultimately with the digestive processes. Any loss of weight which results is therefore pathological.

Sauces

The composition of *sauces*, of which both thick and thin varieties are obtainable, varies greatly. The normal brands now produced are emulsions which make use of vinegar as a basic ingredient, suitable varieties of spices being added to give the characteristic flavour. Stabilisers made from gums or starchy products are often added. Sauces are, in effect, fluid pickles which have little food value, acting mainly as an appetising accompaniment to other foods, particularly meat and fish dishes. Benzoic acid in the ratio of 250 parts per million may be added as a preservative.

Salad cream contains vinegar, spices, edible oil, mustard and egg together with condiments. Some thickening agent such as gelled starch is usually added to give consistency. The entire mixture is homogenised to maintain a stable emulsion and pasteurised before being bottled. *Mayonnaise* is a type of salad cream with a higher oil but a reduced vinegar content. Large quantities of salad cream and mayonnaise are manufactured annually from various types of edible oils and are used for salad dressing and in the production of sandwich spreads. The three main ingredients are egg yolk, oil and vinegar, mixed in varying proportions. Salad cream or mayonnaise must contain not less than per 25 cent. by weight of edible vegetable oil and not less than 1·35 per cent. by weight of egg yolk solids. Frozen egg yolk is normally used. This substance is cheaper than shell eggs and is available at any period of the year. Besides providing a surface film around the droplets of oil, frozen egg yolk also plays an important part in preserving the stability of the final emulsion and influences the blending of the flavours of the other constituents. Dried egg yolk which has been reconstituted may also be used. Highly purified cotton-seed, corn or soya-bean oils are also employed. Soya-bean oil exhibits certain anti-oxidant properties, although it produces a characteristic flavour. Olive oil may be used although its keeping qualities are not so satisfactory. Vinegar acts as a flavouring agent and prevents bacterial growth if present in sufficient concentration. This is important, as final sterilisation of the product is not possible owing to its composition and structure. Both cider and distilled vinegar are used, the former being preferred by some manufacturers. The acidity of the final product rarely exceeds 1 per cent. except in salad cream, which has a higher acetic acid content. The low acid content is insufficient to preserve the product unless the highest-quality ingredients are used and unless the strictest hygienic precautions are employed in manufacture. Sugar is sometimes incorporated as a flavouring agent together with salt. Both should be of the highest quality. Mustard and pepper are also used as flavouring constituents.

In the commonest method of manufacture the egg yolk, spices, salt and sugar are mixed, a small quantity of vinegar being introduced. Stirring is begun, the oil being slowly added. When all the liquid has been incorporated, the remaining oil and vinegar are added to the mixture and the whole thoroughly stirred. Factors which influence the emulsion are: (*a*) the temperature of the ingredients, (*b*) the quantities of the various materials, (*c*) the rate of addition, and (*d*) the emulsifying quality of the egg yolk. The emulsion seldom retains maximum stability during storage, the constituents showing a tendency to separate out. For this reason the final product is either homogenised or viscolised to ensure proper dispersion of the oil throughout the other materials. The emulsion is then filled into glass containers fitted with screwed caps. The containers are filled to maximum capacity, air being excluded. These products should be stored in a cool place to assist preservation. Owing to its higher oil content, great care is necessary in the manufacture of mayonnaise. Both salad cream and mayonnaise may deteriorate following chemical oxidation or the development of rancid flavours and odours due to bacterial action. These defects are closely related to the quality of the raw materials and to the hygienic measures practised in the producing premises. The eggs may be a prolific source of bacterial contamination and off-flavours. The equipment must be maintained in a thoroughly clean condition, particular attention being paid to glass containers. In this connection the screwed-on covers should not be overlooked. Special care must be taken to cleanse the plant owing to the oily film which clings to all parts of the apparatus, and which, if not removed, will accelerate rancidity. Failure to maintain an adequate hygienic standard will assist bacterial development and cause spoilage.

Tomato ketchup is prepared from concentrated tomato pulp and juice preserved with sugar, vinegar and spices. The ingredients are cooked until the desired consistency has been reached. The mixture is strained to remove foreign matter, e.g. particles of spice, and to impart a smooth texture. It is then poured into heated bottles and pasteurised. Concentration may be carried out in open kettles heated by steam or in vacuum pans, the latter method conserving both colour and flavour. It is then filled into bottles at a temperature of 180° F. and sealed, the containers being inverted in order to sterilise the insides of the caps. Equipment should not have any internal surfaces of iron or steel. Iron salts will combine with tannin extracted from the spices, producing black iron tannate ; copper will also affect the colour. Glass-lined or enamelled metal vessels only should be used. The acidity varies from 1·5 to 2·0 per cent.

Salt

Salt is one of our most important food accessories, being the only mineral substance eaten as part of the normal diet. Salt has also considerable value in the various forms of food preservation. It is used for curing fish and meat, in the manufacture of butter, cheese and margarine, by the pickling industry, and in the production of pharmaceutical products and soap. It is also used as a refrigerant. In all cases its purity should be above suspicion. Salt, which has been known since the earliest times, is more appreciated among primitive peoples than is the case in civilised communities, where it is more easily obtained.

The *production* of salt is carried out in various ways. In this country table or culinary salt is most often obtained from *wells* situated in Cheshire and Worcestershire, the deposits below ground being brought to the surface in the form of brine. In Cheshire, brine is often formed by the percolation of the surface water into the salt layer, although the addition of water may be necessary. For this purpose pipes are sunk into the salt-bearing strata. Water is pumped to dissolve the material, which, in the form of brine, is either pumped or forced to the surface by air pressure. The solution is allowed to stand in storage tanks for a few days so that any impurities such as calcium and magnesium sulphates may settle. Abroad, salt is sometimes *mined* from underground deposits, the crude salt being brought in blocks to the surface, where it is further crushed, screened and occasionally refined. When brought to the surface, rock-salt is usually red or brown in colour owing to the admixture of iron salts. It may, however, be grey, due to the presence of bituminous matter. Other impurities such as magnesium salts may also be present. Rock-salt is frequently used for curing meat. *Sea salt* is the term applied to an article produced from sea-water which has been impounded in shallow pits or reservoirs in coastal areas. Evaporation takes place by the action of the air and sun. The proportion of sodium chloride or common salt in sea-water averages 3·3 per cent. This process can only be carried out efficiently in tropical or sub-tropical climates. The salt obtained usually requires further purification owing to the many impurities which it contains. Sea salt contains various micro-organisms in addition to chemical impurities.

The *refining of salt* may be carried out in one of two ways. When the *vacuum-pan system* is employed, the brine is pumped into large vertical pans, where it is heated by steam and subjected to reduced pressure to evaporate its water content. The concentrated salt liquor is removed at frequent intervals from the base of the pan. It is then filtered or centrifuged to remove excessive moisture, being finally dried in rotary driers at temperatures in the region of 350° F. The *open-grain method* is the normal system employed in this country. It is carried out in shallow pans into which the brine is pumped to be heated by steam coils to a temperature of 195° F., large salt flakes being formed. Evaporation is more rapid when open pans are used, as the vapour can freely diffuse. When covered pans are employed, the salt is cleaner, less heat being lost in the process. In this country the brine is so pure that a small stream may be allowed to run continuously into the pans to maintain losses due to evaporation. English brine is highly concentrated, containing between 25 and 26 per cent. sodium chloride and yielding approximately 2½ lb. of salt per gallon of brine.

During crystallisation the brine is allowed to remain undisturbed. The crystals which form are removed up the sloping sides of the pan by means of rakes, to be conveyed to washers and driers, where the remaining moisture is removed. The size and shape of the salt crystals obtained in the refining process depend on the temperature employed. The modern methods used guarantee a uniform product. Vacuum-processed salt is usually uniform in quality with a fine grain. After drying, salt is usually screened into various grades according to the size of the crystals. It is then packed automatically into bags, barrels or cartons, depending upon subsequent use. Salt may also be made into blocks under pressure. Table salt is now being treated with small quantities of organic iodine in the form of potassium iodide. The presence of this substance acts as a preventive against, and in the treatment of, goitre. The iodine content varies from 433 to 725 micrograms per ounce. Small quantities of calcium phosphate or magnesium carbonate may be added to packet salt to prevent stickiness in damp weather and to facilitate free pouring under all climatic conditions. Any addition for this purpose should be stated on the label. The addition of calcium phosphate replaces any phosphates lost in the preparation of food. Potassium chloride may also be added to table salt for similar replacement purposes.

Pepper

Pepper is obtained from a perennial climbing plant, *Piper nigrum*, which is indigenous to both East and West Indies. The berries are removed from the plant as they turn red and are dried on earthen floors, where they may take up a considerable quantity of dirt. As the berries may be imported in this condition and be ground without being cleaned, *black pepper* may contain a large proportion of extraneous dirt or sand. The peppercorns are ground and the material graded by bolting through sieves, the mineral impurities tending to collect in the lower grades. Grades which contain most fibre are sold at a lower price. Black pepper should contain not less than 6·75 per cent. non-volatile ether extract, not less than 30 per cent. starch and not more than 7 per cent. total ash, of which not more than 1·5 per cent. should be insoluble in hydrochloric acid. *White pepper* may be prepared from the black variety, the outer husk being removed by friction after the peppercorns have been soaked in water. The husks are used in the manufacture of sausages and sauces. White pepper is sometimes prepared from the ripe fruits. These are stored for several days, being afterwards bruised and washed until all stalks and pulpy matter have been removed, when the seeds are dried. White pepper is less pungent than the black variety but has a finer flavour. White pepper should contain not less than 7 per cent. non-volatile ether extract, not less than 52 per cent. starch, not more than 5 per cent. crude fibre, and not more than 30 per cent. total ash, of which not more than 0·3 per cent. should be insoluble in hydrochloric acid. To satisfy public preferences the best grades are often bleached. This produces a good colour, hydrochloric acid being employed after the pepper has been tinted pale yellow by the use of turmeric. The pepper is washed to remove all traces of acid, much of the flavour being lost in the process. Pepper treated in this way often exhibits a musty odour. Pepper owes its pungency to an acrid resin, and its flavour to a volatile oil which averages 2 per cent. of the whole. The yellow crystalline alkaloid piperine is also present, together with piperidine, fibre and starch. Black pepper, although mainly used as a condiment, may be prescribed therapeutically in doses of 5 to 20 grains, its medicinal action being similar to that of a volatile oil. Pepper is frequently adulterated with the bleached husks of black pepper, ground olive stones and rice flour. Other materials, such as linseed, gypsum, lentil seeds and palm-nut powder, have also been used as adulterants. The addition of magnesium carbonate has likewise been reported.

Red pepper is prepared from several species of capsicum which yield substances of varying pungencies when ground. *Cayenne pepper* is the most pungent variety. It should contain not less than 15 per cent. non-volatile ether extract, not more than 1·5 per cent. starch and not more than 8 per cent. total ash, of which not more than 1·25 per cent. should be insoluble in hydrochloric acid. *Paprika*, which is deep red in colour, is sweet and pungent. It is a rich source of ascorbic acid, containing approximately 0·2 per cent. It is appreciably milder than any of the other red varieties of pepper already described. Paprika should contain not more than 18 per cent. non-volatile ether extract, not more than 23 per cent. crude fibre and not more than 8·5 per cent. total ash, of which not more than 1 per cent. should be insoluble in hydrochloric acid. Spanish red pepper, or *pimento*, is mainly used in salads. It should contain not more than 18 per cent. non-volatile ether extract, not more than 21 per cent. crude fibre and not more than 8·5 per cent. ash, of which not more than 1 per cent. should be insoluble in hydrochloric acid. The added pungency of red peppers are due to their capsicum content. The *chemical examination* of pepper is usually directed to ascertaining the ash, fibre and added mineral matter contents.

Mustard

Mustard is a popular condiment and is prepared by grinding mustard seeds of the black or white and yellow varieties. The plants are harvested and threshed, care being taken to avoid loss of seed, which is ground into flour. The quality of mustard suffers if it is harvested in wet weather. The hulls are removed from the resultant flour by dressing, although the fibre content may be higher if removal is incomplete. Black and brown mustard flours, which have most aroma, contain the greatest quantity of volatile oil, up to 2 per cent. being present. Both varieties contain between 27 and 38 per cent. fixed oil, together with ash, sulphur, nitrogen and moisture. The pungency and odour of mustard is due to the essential oil. Commercial mustard is usually a mixture of the black and white varieties. Starch is not normally present. This simplifies detection of the common adulterants, such as rice or wheat flours. In certain circumstances, however, starch may be added to assist grinding operations, to improve the keeping quality of the finished product and to reduce bitterness. This constitutes an offence under the Food and Drugs Act, 1938, unless the article is sold as a mixture. Turmeric is occasionally added. This is not considered an adulterant, although it should be absent when mustard is used for medicinal purposes. Some of the fixed oil content may be removed. Although this is an abstraction which should be stated on the label, it improves the final article by preventing rancidity. When used as a condiment, mustard stimulates the secretion of saliva. Mustard also exhibits many medicinal properties, being mainly used as a stimulant emetic. It can also be used as a counter-irritant. Mustard baths are prescribed in cases of chill or influenza. *French mustard* is mustard mixed to a thick paste with vinegar and sold in bottles or jars. The *chemical examination* of mustard is usually directed towards ascertaining the starch and volatile oil contents.

Pickles

The trade of preserving vegetables in vinegar to form pickles has increased in recent years and is now substantial. Onions, cauliflowers, green and red cabbages, small cucumbers, or gherkins, mangoes, walnuts, tomatoes, beetroot, carrots, marrow, dried fruits and apples, with flour, molasses, sugar, gum tragacanth, garlic, spices, saccharine, dulcin and malt or non-brewed vinegars, are the main constituents of pickles, the particular ingredients depending upon the type of article desired. The proportion of these individual substances incorporated in the product vary to a greater or lesser degree. The vegetable ingredients are usually steeped or boiled in saltpetre or vinegar. As their moisture content is high, only the strongest vinegar is used. Malt vinegar is used for the better varieties of pickles, dilute acetic acid, obtained from acetate of lime, being substituted in the cheaper types. Salt plays an important part in the pickling process, setting up osmotic processes which withdraw a portion of the moisture, carbohydrate and soluble nitrogen content from the vegetables. Only the soundest fruits and vegetables should be used in manufacture. High-grade salt, free from impurities, is also essential. Pickles manufactured from fruit and vegetables are permitted to contain benzoic acid as a preservative to the extent of 250 parts per million. Many pickle factories are adequate in all essential details, although the manufacture of pickles and sauces is still too often what might be termed a " back-yard " industry. Numerous small firms have commenced operations during the last few years. Many such firms operate in unclean premises, using insanitary equipment, while conditions of personal hygiene may be indifferent. Whilst appreciating existing difficulties, more attention should be paid to these important points by producers and supervising officials.

Spices and Condiments

Spices and condiments are noted for their aromatic or savoury flavours. These are useful in improving the taste or adding to the relish of various types of food. Spices and condiments are also employed as seasoning agents and as appetisers. They have been used to improve the flavour of low-grade foods. If used in excess these substances will disguise the natural flavour of a foodstuff, while their use may hide the fact that the food has been poorly cooked. They have little or no food value but make it possible to enjoy foods which might otherwise not be appreciated. Certain types of condiments, such as mustard and pepper, have already been considered. Many other varieties exist. These are dealt with below, having been classified so far as is practicable according to their derivation.

Most spices and condiments are obtained from the *stems and leaves of plants*. *Sage* is the dried leaf of *Salvia officinalis*, its flavour being almost entirely due to the aromatic oil present in the leaves. This oil exhibits both astringent and tonic properties. Sage is produced by drying the leaves and stems of the plant. It should not contain more than 12 per cent. stem and other foreign material. Dried sage in packets finds a ready sale to-day. *Marjoram* is obtained from *Marjorana hortensis*, a native plant of North America, while it is grown as a garden herb in many countries. Marjoram is used as a food-flavouring material and is also incorporated in medicinal preparations. *Peppermint* is a volatile oil obtained from the leaves and tops of *Mentha piperita*. It should contain not less than 50 per cent. menthol. It is used as a flavouring material for confectionery and medicinal preparations. A closely-related volatile oil is *spearmint*, obtained from the plant *Mentha spicati*. This oil is easily distinguished from peppermint oil and is used chiefly in the manufacture of confectionery and chewing gum. *Culinary mint* is derived from the garden herb *Mentha viridis*. Mint consists chiefly of the leaf but may contain small portions of the stalk which obtain entrance when the leaves are rubbed. It is used in salads and is sold in prepared form as mint sauce in bottles. Ailanthus leaves have been used as an adulterant. *Thyme* is the dried leaf and flowering top of *Thymus vulgaris*, grown almost universally in temperate climates. It contains a volatile oil, one of the main constituents of which is thymol. It is used as a flavouring material for foods. *Tarragon* is a condiment used either green or in a dried state. When dried it is often canned. The dried leaves and flowering tops of *Artemisia dracunculis* are used in France to distil an essential oil. The oil is incorporated in salads and used for flavouring soups. It is also used in the production of tarragon vinegar. The volatile oil *wintergreen* is distilled from the leaves of *Gaultheria procumbens*, which grows wild in many parts of North America. It is used for flavouring confectionery and beverages, and also as a constituent of embrocation. *Sweet birch oil* resembles wintergreen oil in many respects and is often used in its place. *Bay leaves* are the dried leaves of *Laurus nobilis*, a plant cultivated in the temperate zones, and particularly in the Mediterranean areas. It is used as a flavouring material for various types of food.

The *roots* of certain plants provide well-known flavouring substances, of which *ginger* is probably the best known. This substance is obtained from the roots of the herb *Zingiber officinalis*. The roots are scalded and dried quickly to produce what is known as black ginger. The white or Jamaican type is obtained by peeling or scraping the fresh roots, which are then macerated in water or lime-juice and dried in the sun. The peeled roots may be bleached with sulphur dioxide or dipped in lime-water or calcium sulphate and water, although the use of such materials is officially prohibited. The bleaching process is normally confined to the inferior grades. Ginger is sometimes coated with calcium carbonate or calcium sulphate to prevent infestation by insects. It contains volatile oil, resinous material and starch. Flavour is due to the oily content, the resinous matter being responsible for the characteristic pungent odour. Ginger has many uses. The undried root is used in the manufacture of pickles. As crystallised or preserved ginger, it is used for confectionery purposes following saturation in sugar syrup. The dried root is extracted for the production of ginger-ale or ginger-beer and for use in medicinal preparations and perfume manufacture. Ginger has been found adulterated with turmeric to restore its yellow colour, and with cayenne to provide the necessary pungency. *Garlic*, obtained from the root of *Albium sativum*, owes its characteristic flavour to the essential oil which it contains. It is extensively used in cooking and in the composition of salads, particularly in Mediterranean areas. *Horse-radish* is the root of the plant *Cochlearia armoracia.* It contains a volatile oil which is responsible for its pungency and which is quickly dissipated by exposure to light and air. It is usually shredded as a constituent of salads or grated and mixed with vinegar to form a sauce. Horse-radish cream or sauce must contain not less than 25 per cent. by weight of horse-radish root or its equivalent in dehydrated horse-radish root and essential oil of the root. *Turmeric* comes from the East Indies and is a member of the ginger family. To produce turmeric the root of the plant *Curcuma longa* is dried and thoroughly ground. It is used both as a colouring and as a flavouring agent. The colouring agent, curcumin, is yellow. Its main constituents are cellulose, gum, starch and a volatile oil. Turmeric has been used as an adulterant for ginger and mustard. The best-quality *sassafras* is produced from the roots of *Sassafras varifolium.* The volatile oil is occasionally extracted for medicinal use. The ground root is used in the production of aerated or carbonated beverages.

Both cinnamon and cassia are derived from *barks. Cinnamon* is the dried inner bark of *Cinnamonum zeylanicum* and is known commercially as Ceylon cinnamon. Ground cinnamon is the powder produced from the bark. Long strips of the thin bark are removed from the trees, cured, slightly fermented and dried, reaching the market in the form of long, thin quills. Cinnamon contains from 0·5 to 1·0 per cent. of sweet essential oil, the main constituent of which is cinnamic aldehyde. This supplies the characteristic pungent odour. It is used in medicinal preparations and in the manufacture of confectionery. Two types of *cassia* are produced. The variety which may be considered as a spice is produced from the bark of *Cinnamonum aromaticum.* Being less costly than cinnamon, it is often used either as an adulterant or as a substitute. The essential oil bears a strong resemblance to that of cinnamon and is used for scenting various types of soap. Cassia consists of the entire bark and is considerably thicker than cinnamon quills. As it retains its natural outer surface, it is easily distinguished from cinnamon. The dried flower buds are occasionally used for flavouring purposes. The medicinal type of cassia is an extract obtained from the pulp of the crushed ripe fruits of *Cassia fistula.* These are known commercially as cassia pods.

The *flowers or buds* of certain plants are used in the production of spices. *Capers* are the pickled flower-buds of *Capparis spinosa,* which is allied to the nasturtium family. The buds are picked when almost mature, dried in the air for twenty-four hours and pickled in strong white vinegar, being sold in bottles. Brine is also used for pickling purposes. The characteristic flavour is due to the capric acid content. Capers are usually graded according to size, the smallest being most acceptable. They are mainly used to flavour meats and pickles. Nasturtium seeds have been used as an adulterant. The flower-buds of *Caryophyllus aromaticus* are dried to form *cloves.* The value of cloves depends on the volatile oil content, which should be approximately 17 to 20 per cent. Caryophyllin is an important constituent. Resin, fixed oil and quercitannic acid are also present in varying quantities. The oil may be removed before the buds are ground. This deception is not uncommon. Cloves may be adulterated with dried exhausted cloves, which, when whole, exhibit a shrivelled appearance. Pimento is sometimes substituted, since it exhibits a clove-like aroma. The dried stigmata of *Crocus sativus* provide *saffron,* used for medicinal purposes and as a flavouring agent. Saffron is also employed as a colouring matter for food.

Certain spices are produced from the *immature or ripe fruits* of plants.

Juniper is the aromatic dark-blue fruit of *Juniperus communis.* It is used as a flavouring agent for both corned beef and gin. Its oil has a powerful diuretic action. *Pimento,* or allspice, is a small dry berry obtained from the nearly-ripe fruit of *Pimento officinalis.* It differs from cloves, to which it is closely related, in that it contains a considerable quantity of starch. Its essential oil is aromatic and pungent, resembling clove oil, for which it is sometimes substituted. It also contains tannin. *Vanilla* is extensively used as a flavouring agent by the food trades. The vanilla bean is the fruit of the plant *Vanilla planifolia,* which grows in various tropical zones. The bean is gathered when it is yellowing-green in colour, although when harvested the characteristic odour and colour are lacking. The beans are allowed to sweat, during which time both odour and colour develop. Fermentation is very often carried out by placing the beans between blankets in the open, alternatively covering the beans and exposing them to the sun's rays. Artificial heating in ovens is also used. During this process the beans become dark brown and develop their normal odour. After the fermentation process is completed, the beans are dried. They are some 8 to 10 inches in length, are soapy or greasy to the touch and covered with vanillin crystals. These crystals contribute considerably to the flavour and odour. Other substances contribute to flavour and odour in the highest-quality beans, which also contain fat, wax, sugar, gum, resin and tannin. The vanilla extract known to commerce is obtained by extracting the beans with dilute alcohol, cane sugar being added. A number of imitations are prepared from coumarin, vanillin and Tahiti beans. Synthetic vanillin is produced by oxidising the eugenol derived from the oil of cloves with potassium permanganate.

Many spices and flavouring materials are derived from *seeds. Aniseed* is the dried fruit of *Pimpinella anisum,* from which is obtained an oil with a highly aromatic flavour. Aniseed is used to flavour confectionery, pastry and beverages. *Caraway seeds* are obtained from the dried ripe fruits of *Carum carvi.* They yield the essential oil, carvol. The seeds are used as flavouring agents. Dill seed has been offered as a substitute. *Cardamon seed* is obtained from the dried nearly-ripe fruit of the diminutive tree *Elettaria cardamomum.* The seeds, which receive repeated washings in soap solution before being dried, are used as a flavouring agent for beverages, confectionery and other foods. The oil of *bitter almonds* is extracted from the seeds of bitter almonds, apricots and peaches. As the oil contains hydrocyanic acid, this substance must be removed by chemical separation. *Celery seed* is the dried fruit of *Celeri graveolens.* It is used to flavour pickles and other seasoned foods, such as soups. *Coriander seed* is obtained from *Coriandrum sativum.* Its flavour, which is mainly due to the volatile oil content, is extensively used in the manufacture of confectionery, pastries, soups and other foods. *Cumin seed* is the dried fruit of *Cuminum cyminum.* It is used in pickles, soups and other foods. Cumin seed has a special use in Germany, where it is added to certain types of bread ; in Norway it is employed in the preparation of anchovies. In Holland it is sometimes used to flavour cheese. *Dill seed* is the dried fruit of *Anethum graveolens.* It is extensively used to flavour sauces and as a general condiment. In America dill pickle is flavoured with dill seeds. *Fennel seed* is sweet and aromatic, due to its volatile oil content. In some countries the seeds, which are the dried fruit of *Fœniculum vulgare,* are used for oil production. *Mace* is the dried arillus of *Myristica fragrans,* which is also the source of nutmeg, the mace being the outer coating of the arillus. Mace is sometimes adulterated when sold in a ground condition. Its composition is similar to that of *nutmeg*, which is the kernel of the fruit. The nuts are gathered and smoked until the shell can be cracked and the kernel separated. Nutmeg contains between 25 and 35 per cent. fixed oil, and between 2·5 and 3·5 per cent. volatile oil. Nutmegs are usually treated with lime to prevent germination and attacks by insects. Both mace and nutmeg have a pungent flavour. Nutmeg sold in ground condition has sometimes been found to contain cereal materials. *Paradise seeds* are obtained from *Amomum melegueta.* They have a pungent odour, being extensively used for flavouring liqueurs. *Tonka beans*, which yield coumarin, a material used as a substitute for vanilla in the preparation of vanilla extract, are the seeds of the tree *Coumarouna odorata.*

CHAPTER XX

CONFECTIONERY AND PRESERVES

THE various food articles which fall within the definition of confectionery and preserves include not only chocolates and sweets but also jams, marmalades and jellies. As sugar is one of the main ingredients of all these sweetened foods, consideration must be given to sugar before mention is made of the various products of which it is a prime constituent.

Cane Sugar

The sugar-cane, from the juice of which cane sugar is produced, is grown in many tropical and sub-tropical countries. Sugar is a colourless syrup which becomes crystalline on refining, and chars when heated. It is soluble in water. Sugar is very liable to fermentation ; it is thus of great assistance in processes where such changes are required. The manufacture of sugar is a long and complicated process. In early days sugar was an expensive substance, being used mainly for medicinal purposes or as a condiment. Improved methods of production, together with a fuller realisation of the importance of sugar as a food substance, have led to an increased demand from all sections of the community, and has brought about considerable reduction in price.

When the canes have been gathered and transported to the mill, a *crushing process* extracts the juice. The canes are sliced, shredded or cut into small pieces. This preliminary treatment facilitates extraction of the juice and prevents choking of the rollers in the crushing mills. The crushing apparatus has several grooved or toothed rollers, through which the pieces of cane are passed. Three sets of crushing apparatus are usually provided so that the maximum amount of juice is expressed from the material. The first crushing will remove approximately 60 per cent. of the juice. Water or dilute juice is usually added to the cane during the final crushing operation. The woody fibrous matter which remains after the juice has been extracted is known as "*megasse*". In order to remove the fragments of fibre contained in the expressed liquid, it is strained by mechanical strainers through perforated brass plates, or with stainless metal wire cloth.

Purification follows. In order that the greatest quantity of impurity can be removed from the juice as soon as possible after crushing, lime and heat are employed. The quantity of lime, the method of addition and the temperature to which the juice is heated vary according to local circumstances. An agreed quantity of milk of lime is mixed with a known weight of cold juice, a pH determination apparatus being employed to adjust the liquid to the desired hydrogen-ion concentration. A pH of 8 to 8·5 gives the most satisfactory results. The clarity of the juice, the inversion of sucrose and destruction of glucose, together with the increase in purity and volume of settling, each play a part in determining the final pH. When the lime has been added, the temperature of the mixture is raised to boiling point. A flocculent precipitate forms. This contains calcium phosphate and other insoluble salts and carries down the finely-divided material contained in the juice, including the coagulated albumin, fat, gum and wax. The juice is allowed to settle and the clear liquid drawn off. The precipitate is pressed to express a further quantity of juice. This is mixed with the juice already obtained, the clarified liquid being thereafter concentrated in vacuum evaporators to a syrup which contains between 35 and 45 per cent. moisture.

Crystallisation of the syrup produced by evaporation is next carried out. This liquid or syrup is further evaporated in vacuum pans until it becomes a saturated solution of sugar, crystals of sugar separating out. As the water content is evaporated more syrup is added to the evaporator, sugar being deposited on the crystals already formed. The final mixture of sugar crystals and syrup is termed "*magma*." This substance is subjected to centrifugalisation, being placed in perforated metal baskets which have a lining of wire cloth and perforated bronze sheets. The sugar crystals remain in the basket during the process, the molasses liquor being discharged through the perforations by centrifugal force. The brown crystals, to which a portion of the syrup still adheres, are known as raw sugar, further treatment being required to produce the white crystalline substance in common use. The molasses removed by the centrifuge still contain some sugar. It is therefore mixed with a further batch of syrup and returned to the vacuum pan. This magma is again centrifuged ; the molasses are once again evaporated in the vacuum pan. This process is repeated three times. The two higher grades of sugar are bagged, the lowest grade being once again returned to the vacuum pans to assist in the production of the higher grades. When the sugar content of the molasses is insufficient to allow economical removal of further sugar, it is discarded and finds a ready sale for fermentation processes.

The raw sugar is packed in jute sacks for transport to this country and is known as brown or Demerara sugar. When a white sugar is to be produced, a lengthy and complicated *refining process* is carried out. The sugar is first emptied into hoppers. It then passes to the washing apparatus, the sacks being also washed to recover any sugar adhering to them. *Washing* marks the beginning of the refining process proper. As received, the sugar crystals are coated with a thin layer of molasses. This is removed by mixing the raw sugar with syrup, the mixture being centrifuged and the crystals washed with water. Part of the wash liquid is collected, diluted, heated to 120° F. and used again for mixing with more raw sugar. The process of centrifuging may operate continuously, the wash water being changed every twenty-four hours. *Melting* of the washed sugar then takes place, water being added and the whole dissolved by means of mechanical stirrers. The quantity of water used approximates to 50 per cent. of the weight of the sugar being treated. Washing will only remove surface impurities from the raw substance. After melting, the liquid syrup is acid in reaction.

Defecation, which follows, is brought about by the use of lime. This substance is added until a pH of 7·3 to 7·6 has been obtained. The temperature is raised to 180° F., more lime being added to neutralise acidity. A precipitate is formed which carries down the finely-divided suspended matter, including the pectins, albumins and gums. Various materials, such as diatomaceous earths, paper pulp or kieselgurh, are mixed with the syrup, which is pressure filtered to remove suspended matter. Sulphur dioxide is sometimes used for clarification purposes. The filtrate is clear but coloured. *Removal of the colour* by filtration through bone black or animal charcoal is next carried out. Filtration takes place in tall filters, which remove both organic and inorganic impurities. Approximately $\frac{1}{2}$ to 1 lb. bone black per pound of melted sugar is required for filtration purposes, the liquid, at a temperature of 160° F., taking three to eight hours to flow through the filter. Filters are usually cleansed with hot water at 210° F. The first washings are saved as they contain a suitable concentration of sugar which may be salvaged.

The *boiling process*, during which crystals are formed, is carried out in vacuum pans so that low temperatures may be used to drive off moisture. If the sugar were boiled at atmospheric temperature it would not crystallise but would caramelise and form a reddish-brown substance. When large crystals are required, a small volume of liquor is used during the early stages of the operation, a limited number of crystals being allowed to form. As more liquor is added to the pan the size of the crystals increases, additional sugar being deposited on those already formed. Small crystals are obtained by placing an initially large volume of liquor in the pan. The boiling of sugar is an extremely skilled operation, control of temperature and vacuum being vitally important. Granulated sugar requires a temperature of between 160° F. to 180° F. in the pan ; 120° F. to 130° F. is sufficient when soft sugar is being produced. The residues which remain after boiling are sold in the form of treacle or syrup.

Curing follows, the material from the vacuum pans being centrifuged to separate the syrup from the crystals of refined sugar. Water or steam is sometimes applied during the process for the purpose of washing the syrup from the crystals. The sugar crystals are then dried and cooled by passing through two or at most three revolving drums, after which they are *sieved and graded* according to the size of the crystals. Dust and lumps are removed during this process. The sugar is finally packed in 100-lb. bags or in cartons. A proportion may be pressed into cubes for table use.

Sugar is a useful preservative. The types of bacteria which normally cause spoilage do not usually grow in 50 per cent. sugar solutions, although yeasts and moulds will continue to act up to saturation point. Sugar in strong concentration will not destroy bacteria but will prevent their growth. Sugar melts at 160° F. ; heating to 200° F. yields a brown amorphous substance termed caramel, which is used as a colouring and flavouring material. Adulteration of sugar is rare, although white sugar may be coloured by caramelisation or by means of aniline or vegetable dyes. It is then sold at a higher price as Demerara or brown sugar. The presence of a dye, however, does not necessarily mean that the sugar has been adulterated, since West Indian sugars are often coloured. Dyed samples generally turn pink if a small quantity of hydrochloric acid is added. Alternatively, the suspected sample may be extracted with absolute alcohol, which removes the foreign colouring matter, leaving behind the colourless sugar crystals. Natural colour is not affected by alcohol. If suspected crystals are examined under a lens they wlll usually appear unequally coloured. Ultramarine or dyes of the methyl-violet class are sometimes added to white sugar to improve its appearance. These substances may be detected by means of a lens or by allowing a solution of the suspected sugar to settle. Sugar and cane syrup may contain *preservatives* in the form of sulphur dioxide at the rate of 70 parts per million.

Formic acid is sometimes used as a preservative, and may also be produced in brown refined sugar during the refining process. Sugar contaminated by dirt should be condemned, although such foreign substances can be removed by further refining. Sugar may be infested with parasites, while beetles have also been found. Sugar mites are common in brown sugars. These insects are responsible for the skin affection " grocers' itch."

Sugar is usually submitted to *chemical examination* for the detection of adulteration and the presence of preservatives.

Beet Sugar

Large quantities of white beet are grown annually for sugar production, the manufacture of beet sugar having become an important industry in this country. The sugar so obtained has provided a valuable addition to supplies received from abroad, particularly during and since the War. The chemical composition of beet sugar is similar to that of sugar produced from sugar-cane. The process of extraction from the beets has been the subject of considerable effort and research, while the work of the agricultural scientist has enabled a beet to be produced which contains between 15 and 20 per cent. more sugar than was available a century ago. The beets are removed from the ground, trimmed and transported to the factory. In the factory they are thinly sliced and soaked in warm water to form a pulp, the sugar being removed by diffusion. The water is changed some twelve times during the process, a portion of sugar in the pulp being removed at each extraction. The water used for the first extraction is passed over the fresh beet. This process is continued, fresh water being used for those portions of the pulp which have been most extracted. The sugar content of the water increases as the process continues, the final liquor being rich in sugar. The water temperature is maintained at approximately 165° F. This inhibits bacterial growth and increases the rate of extraction. The liquor is next strained to remove remaining portions of the pulp. It is then treated with lime and carbon dioxide, heat being applied to remove impurities. Acidity is neutralised in this way, while organic materials and colouring substances are precipitated. The syrup is subjected to a sulphate treatment which lightens the colour and improves its keeping quality. It is then filtered, the filtrate afterwards being concentrated in vacuum pans. The final processes are similar to those already described in the treatment of cane sugar. Beet sugar contains only sucrose, whereas cane sugar contains sucrose and a small quantity of invert sugar. It is sometimes bleached, either by passing through bone black or by the application of sulphur dioxide.

Glucose

Glucose, which is also known as corn syrup, is produced from maize, rice, potato or corn starch. These substances are boiled with dilute hydrochloric or sulphuric acids until the conversion process has proceeded as far as is desired. If the conversion process is carried to its full extent, dextrose will be produced. The resultant liquid is neutralised, decolorised by active carbon and concentrated, yielding either a thick liquid known as liquid glucose or corn syrup, or a solid substance. The solid variety contains approximately 60 to 80 per cent. dextrose, a small quantity of maltose and some 10 per cent. dextrin. Liquid glucose contains 15 to 25 per cent. dextrose ; half the remaining solids are maltose. Crystalline glucose is prepared by the hydrolysis of pure starch with 0·2 per cent. hydrochloric acid and steam under pressure. If sulphuric acid is used in the preliminary treatment, inefficient manufacturing methods may result in traces of arsenic being present. Glucose is used medicinally, providing energy in a concentrated readily-assimilable form. It is also used by the confectionery trade in the production of sweets, for brewing and syrup manufacture, and in the manufacture of cheap jams and jellies. Glucose is approximately one-third less sweet than sucrose. When used in jams and jellies it tends to inhibit crystallisation if combined with sucrose. Solid glucose may contain sulphur dioxide as a preservative at the rate of 70 parts per million. In the case of liquid glucose and corn syrup, the same preservative may be used at a rate of 450 parts per million.

Dextrose is the most stable of all sugars, is less sweet than cane or beet sugars, produces very fine crystals and is less soluble than cane sugar. It is manufactured from maize starch by conversion with acid and subsequent re-crystallisation, very fine crystals being produced. Dextrose is becoming popular as a sweetening agent for confectionery.

Fructose

Fructose, sometimes known as fruit sugar or levulose, is found in honey and is closely related to glucose. It is also found in many fruits and starches. Fructose can be produced by the hydrolysis of sucrose with sulphuric acid, the invert sugar which is formed containing approximately 50 per cent. fructose. Commercially, however, fructose is more easily obtained from substances of which it is the main carbohydrate constituent, artichokes, chicory and dahlia roots representing the most fruitful sources. Artichokes have an average fructose content of 14 per cent. The roots are dehydrated in slices. This prevents reduction in the sugar content when the slices are extracted with water (see " Beet Sugar "). The extract is acidified to a pH of 1·5 by the addition of sulphuric acid and hydrolysed at 176° F. for one hour. After heating, the pH is adjusted to 7·5 by the use of powdered hydrated lime, calcium sulphate being precipitated. The liquid is filtered to remove coagulated and colloidal matters together with the precipitate. The filtrate is then treated with a suspension of lime, the resultant material being filtered and washed, suspended in distilled water and finally carbonated under 15 lb. pressure at a temperature of 59° F. The precipitated calcium carbonate is removed by filtration, the liquid being evaporated to a 40 per cent. syrup in a vacuum pan at 140° F. Further filtration next takes place. The syrup is then concentrated to 90 per cent., crystallisation occurring while the temperature is gradually reduced. The mixture is centrifuged to remove the molasses, the final crystalline white powder having a fructose content of 98 per cent. Fructose is readily soluble in water and dilute alcohol but not in absolute alcohol. It is sweeter than cane sugar, being more easily assimilated by the body. Fructose has been used to sweeten the food of diabetics, since it does not increase the sugar content of the blood. It is also employed for a further variety of medicinal purposes.

Maple Sugar

Maple sugar is produced in Canada from the sap of the maple tree. It consists of 4 to 8 per cent. of sucrose sugar together with 5 to 10 per cent. of moisture. It is, therefore, never likely to compete with the more easily obtainable sugars. Maple sugar is employed chiefly for culinary purposes or as a low-grade sweetener. The sap is evaporated in an open pan, the scum which forms being removed from the surface of the liquid. Great care must be taken to ensure the complete removal of the scum as this contains nitrogenous substances which may cause fermentation. A heavy syrup is required for crystallisation purposes. The concentrated liquid is usually sold in syrup form, although when high concentrations are made crystallisation occurs. Maple sugar has an extremely white appearance. Owing to its relatively high price, it is often adulterated with cane syrup.

Honey

Honey is a sweet viscid liquid produced by bees from the nectar of flowers and deposited in the cells of the honeycomb. The principal constituent of the nectar is sucrose. Much of this sucrose undergoes inversion into dextrose and levulose in the honey-sac of the bee, due to the secretion of the enzymes diastase and invertase. The flavour and colour of honey varies according to its source. Differences in the aromatic constituents of the plants from which the nectar is obtained alter taste and aroma. The honey produced from white clover has a delicate flavour but is pale in colour ; that from heather has a strong flavour with a rich golden colour. The colour of honey darkens during the autumn months. In addition to dextrose and levulose, honey contains mucilage, wax, essential oil, colouring substances, proteins, dextrin, ash, water and pollen grains. Pollen grains are present even when honey has been filtered and may be identified as emanating from certain types of flowers. Organic acids of various types are also present.

The bees are housed in hives. A favourable climate and suitable flowering plants govern the districts in which honey can be efficiently produced. Severe winter conditions may be harmful to bees. Hives should therefore be constructed with a view to affording adequate protection. The honey is deposited by the bees in wax honeycombs. During conversion from nectar to honey the moisture content is reduced to at least two-thirds of the original. To increase the yield, saccharine solutions are sometimes fed to the bees. In some countries this practice is regarded as a method of adulteration. It is said that honey direct from the comb has the finest flavour, although honey is usually sold in jars, having been extracted from the comb and clarified by heating and skimming. The honey of young bees will readily flow from the comb with or without the application of heat and is generally regarded as being of the highest quality. Honey produced by an old hive of bees is usually darker and thicker and has a less pleasant taste and odour.

When exposed to light and to low temperature for some time, pure honey becomes more or less granular, although the liquid portion can be readily separated by straining through a linen cloth. The main adulterants, which can be readily detected, are starch paste, identified by means of a microscope and by its blue reaction with iodine, wheat flour, gelatine, low-grade malt extract, invert sugar, added water, cane sugar, common syrup and various types of manufactured glucose. Because of their low price, glucose and invert sugar have been frequently used as adulterants and have been found in what was termed " pure extracted honey." Honey should be stored in stone jars, since it may act on the lead glaze of earthenware. Honey exhibits mildly laxative properties and is used as a demulcent and flavouring agent for pharmaceutical preparations. It is also a satisfactory agent for thickening liqueurs and for sweetening imperfectly ripened wines. Ale is sometimes given flavour and strength by the addition of honey, while it can be used domestically for sweetening stewed fruits and in the manufacture of puddings and flour confectionery. When gathered from poisonous plants, honey has been the source of individual cases of poisoning. *Chemical examination* is mainly directed towards the detection of adulterants.

Jam

The term "jam" is popularly applied to preserves manufactured from fruits by boiling with sugar to a suitable consistency. Strictly speaking, however, a product which contains whole fruit is a "preserve" rather than a "jam." Domestic jam-making has decreased within recent years, the factory-made article being produced, in the majority of cases, under strict scientific control which has resulted in a standardised product. All types of fruit are used in jam manufacture. When gathered, the fruit should be of good quality and should be thoroughly washed and soaked to remove extraneous matter. Large fruits may be peeled, stoned or cored; they may be picked or pulped by means of machinery. All fresh fruit contains between 15 and 20 per cent. sugar, with a high moisture content. Decomposition will occur rapidly unless the excessive moisture content is removed or unless the sugar percentage is increased. Jam cannot be manufactured from decomposed fruit, although softened fruit can be used if free from mildew, fermentation or decomposition. Large quantities of imported fruit pulp are used for jam-making. Preservatives are allowed as follows :—

Cherries	3,000	parts per million of sulphur dioxide
Raspberries and strawberries	2,000	,, ,, ,, ,, ,, ,,
Other fruits . . .	1,500	,, ,, ,, ,, ,, ,,

Pectin must be added to certain soft fruits, such as strawberries, to give body to the product and to ensure that it will "set" properly. Fruits which are deficient in pectin and acid at certain seasons of the year also set badly. The addition of pectin or acid enables the manufacturer to produce a standard article at all times of the year, although it should be noted that these substances are occasionally employed to mask the use of out-of-condition fruit and to cover deficiencies. Apple and gooseberry juice are frequently added to improve the gelatinising power in place of pectin. Agar-agar and Iceland moss have been used for the same purpose, while gelatine has been employed in low-grade articles. Pectins, which are sold in purified and concentrated form as thick liquids or dried powders, are devoid of food value when artificially produced. Chemically they are members of the carbohydrate family. When used commercially, pectins should exhibit a high, or at least a standardised, jelling power, so that definite quantities can be used to obtain the desired result. They should not add any flavour or odour to the jam. Setting is determined by the proportion of sugar, pectin and acids which the jam contains. Between 0·5 and 1·0 per cent. of pectin is usually required in order to provide a jelly strong enough for commercial purposes. The acidity of the product may be increased by the addition of fruit acids, citric, malic and tartaric acids being used for this purpose. It was formerly the custom in jam-making to add 1 lb. of sugar for each pound of fruit. The quantity of sugar used in modern jam production varies according to the acidity of the fruit, its sugar content, ripeness and the type of jam being produced.

When the fruit has been prepared, the required quantity of sugar is added, the mixture being heated in steam-jacketed pans, kettles or, if the fruits have delicate flavours, in vacuum pans. Although in the past cane sugar only was used, large quantities of beet sugar are now employed in jam-making. Glucose is also extensively employed, particularly in the cheaper varieties of jam. The use of glucose is not considered a form of adulteration even when it is present to the extent of 13 per cent. Glucose results in the production of a slightly more aqueous and gelatinous mass which, it is claimed, is not subject to crystallisation. As already stated, inferior glucose may be the source of arsenical poisoning. Lemon juice, which will also prevent crystallisation, is sometimes included. The proper boiling temperature of the mixture depends upon the sugar concentration. Thermometric methods should always be employed to determine the correctness of the process. The boiling period can be shortened by the addition of extra pectin, by additional steam coils in the boiling pans, or by pre-concentration of the juice or pulp under vacuum. If the boiling period is too short an excess of moisture, leading to fermentation, will result; excessive heating will affect both colour and flavour, the setting power of the pectin and produce crystallisation. Jams manufactured from small batches of fruit and sugar are less liable to such changes, while their quality is usually higher. When large batches of fruit are processed, the period of heating for each pound of the mixture is lengthened. The desirable aromatic constituents may then be volatilised, the resultant jam being discoloured and affected both by oxidation and metallic contamination. Minimum boiling will suffice when proportions of sugar, pectin and acid are correct. When boiling has been completed, the jam is generally packed in glass containers, although substantial quantities are packed in cans or stone jars. The jars are either vacuum-sealed or have the surface of the jam protected by a circle of waxed paper to prevent mould development.

Jam is now graded to various standards. *Full-fruit standard jam* must contain 20 to 40 per cent. fruit, according to type. The percentage of soluble solids should not be less than 68·5 per cent. Lower-standard jams may contain less than 20 per cent. fruit. *Fresh fruit standard jams* must have a similar composition but must not contain any added colouring matter or preservative other than sugar. The sugar content of jam is such that any spoilage due to bacterial action is prevented. Jams may be further heated in their containers, although flavour and colour are altered by this process, which is often noticeable in canned preserves. Cooling after heating should be carried out as quickly as possible. The lower-grade jams are usually employed by bakeries for use in flour confectionery products. No cases of human infection caused by the consumption of jam have been reported. Preservatives are allowed in the ratio of 40 parts per million of sulphur dioxide, although preservatives are rarely found in good-quality jams, which contain sufficient sugar to prevent spoilage during storage. *Chemical examination* of jam is mainly directed towards determining the quantity of preservatives present, the use of artificial colouring matters and gelatine, the estimation of acidity, the fruit content and the use of foreign seeds, particularly in raspberry jam. Aniline dyes have been used for colouring jam; adulteration by the incorporation of mangold or turnip pulp may be found. Apple pulp and pulp obtained from cheap fruit are often incorporated in low-quality jams, without any notice being given to the consumer. This is not recognised as adulteration in the strict sense of the term.

Fruit curd is usually manufactured in the form of lemon or orange cheese or curd, being a mixture of eggs, lemon or orange juice and sugar, mixed thoroughly and heated. The substance is then packed in glass containers which are suitably sealed. Fruit curd should contain not less than 65 per cent. of soluble solids, while each 100 lb. of the substance should contain not less than 4 lb. of fat, 0·33 lb. citric acid, 0·125 lb. oil of lemon and 1 lb. of dried egg. The dried egg may, if desired, be replaced with either 4½ lb. of shell egg per 100 lb., $1\frac{1}{2}$ lb. sugar dried whole egg, or $3\frac{3}{4}$ lb. liquid frozen whole egg. In the case of orange curd, the oil of lemon is replaced by 0·25 per cent. oil of orange. *Mincemeat*, which is a mixture of fruit and peel, sugar and suet or other fat, is manufactured in large quantities for the Christmas season. The ingredients are chopped and cut, thoroughly mixed, and packed in glass jars. Each 100 lb. of mincemeat should contain not more than 0·5 per cent. of acetic acid and not less than 30 lb. of sugar, 30 lb. dried fruit and 2·5 lb. of suet or other fat. The total solids content should not be less than 65 per cent.

Marmalade

Marmalade is an orange jelly in which pieces of the peel are embedded. Seville or bitter oranges are used in the manufacture of marmalade in this country to provide the popular bitter flavour, although other types of marmalade are also produced. Ginger marmalade, in which preserved ginger features as the main constituent, is also manufactured in Great Britain together with lemon, lime and a mixture of citrus fruits marmalade. Large quantities of canned grape-fruit and sweet orange marmalade have been imported. In America oranges and grape-fruit are mixed, while oranges can be mixed with lemons, as the sweet oranges do not usually furnish sufficient pectin and acid. English marmalade is produced in two varieties. The most common type includes the fruit pulp in addition to the peel, which is often thickly cut. The second variety (jelly marmalade) is a clear orange jelly in which thinly-cut strips of peel are embedded.

Several methods of production are employed. The fruit is peeled, the pith and seeds being removed. The fruit is then sliced or broken up and boiled. If jelly marmalade is required, the juice is extracted. The peel is cut into the desired sizes and is often boiled separately in water to which small quantities of sodium carbonate or ammonia have been added to facilitate softening. Alternatively, the peel may be treated with steam under pressure. The peel and pulp are then united. The sugar is added, the mixture being finally boiled. In some cases the fruit is cut into halves, the juice being filtered off. The peel is sliced, boiled until soft and added to the juice. This is heated and mixed with a portion of the sugar, pectin being often added. The whole is then thoroughly boiled, the remaining sugar being incorporated into the mass together with a small quantity of citric acid. There should be no crystallisation of the sugar in the final product. This is avoided by adequate boiling or by increasing the acidity of the mixture. After boiling, the marmalade is filled into jars which are sealed in a manner similar to that described in relation to jam.

The *special standard variety* of marmalade must contain not less than 68·5 per cent. of soluble solids. If of the *jelly type*, the fruit content should not be less than 20 per cent. of the whole, but if it is the *coarse-cut variety*, a 30 per cent. fruit standard is necessary. The *full-fruit type* must possess between 20 and 40 per cent. fruit, and the lower fruit variety may have less than 20 per cent. fruit. Grape-fruit marmalade must have a fruit content of not less than 25 per cent. Preservatives may be added to all types of marmalade but are limited to 40 parts per million of sulphur dioxide. Preservatives are rarely used in good-quality products as the sugar content is sufficient to prevent deterioration prior to sale. Low-grade marmalades may contain gelatine, used for thickening purposes; glucose may be employed in place of sugar as a sweetening agent. *Chemical examination* is mainly directed towards estimation of the quantity and type of preservative used, the addition of gelatine, acidity and the fruit content.

Jellies

The production and sale of jellies has developed rapidly during the last twenty years. Jellies prepared for the table are highly popular sweetmeats. Jelly is produced from a combination of fruit juices and sugar. Fruits which do not contain sufficient pectin and free acid in adequate concentration are unsuitable for incorporation in jellies. Some fruits may contain a sufficiency of these substances. If used for jelly-making, the deficiency in the missing substance must be supplemented from other sources. This may be achieved by a combination of fruit juices or by adding pectin or fruit acid.

Jellies should have a uniform colour, flavour, firmness, texture and clarity. These characteristics depend on the fruit, the contained pectin, the acid content and the quantity of sugar added. When mixed with water and cooled, the consistency of the final product should be sufficient to retain the shape of the container. When cut, the exposed surface of the jelly should be clean and smooth. The final product should be perfectly clear, while no liquid should separate from its surfaces. The fruit juices used in the manufacture of jellies are obtained by boiling the selected fruit in water, the quantity depending upon the type of fruit. The mixture is then strained or filtered to remove the pulp and seeds. Solid fruits require more water and longer heating as compared with berry fruits. Fruits in which the flavour has fully developed prior to total ripening usually produce the finest jellies. Juicy fruits may be extracted twice. Whatever type of fruit is used, the heating process should be strictly controlled so that flavour is not lost or pectin hydrolysed and converted into pectin acid. The containers used for boiling should be either glass-lined or constructed of stainless steel. Other metals, e.g. copper, may produce colour defects. With solid fruits the pulpy mass may be pressed through filters after boiling to extract the juice. Several extractions may be made. The juice is clarified by various methods, settling tanks, pressure filters and centrifuges being used for this purpose. Sugar is then added to the boilers in relation to the acid and pectin content of the fruit as determined by laboratory examination. The addition of too small a quantity of sugar usually results in the production of a tough jelly ; if the sugar content is too high, the final product may be soft and easily broken. The mixture should be standardised to a pH of 3·2 to 3·5. Increased acidity reduces the quantity of sugar required ; excessive acidity results in separation of the liquid from the surfaces. If desired, fruit acids, fruit juice rich in pectin or commercial pectin may be added to the mixture.

Boiling is continued to concentrate the juice until it is certain that the liquid will form a suitable jelly when cooled. A film of coagulated fruit protein forms a scum on the surface of the liquid during the process. This has to be removed at the proper time, otherwise clarity will be impaired. Excessive boiling induces changes in colour and flavour and reduces the pectin content. Vacuum pans using lower temperatures may be successfully employed. In such cases citric or malic acid may be added to assist inversion of the sugar. Various methods are employed to determine the end-point of the process, refractometers, thermometers and hydrometers being used for this purpose. The jelly strength is usually satisfactory when sugar concentration is between 65 and 69 per cent. The final consistency depends upon the amount of sugar, pectin and acid present, the duration of heating and the lack of agitation during cooling and setting processes. The liquid is next cooled. Agitation should be prevented during this process. It is then placed in jars which are sealed in the usual way. Jellies may be adulterated by the addition of gelatine, while foreign colouring matters have also been used. Preservative in the form of sulphur dioxide is limited to 40 parts per million. Low-grade jellies or conserves are often used by bakers for confectionery fillings.

Table jellies, which are more solid than the type just described, may be flavoured with or produced from fruit, but are usually manufactured artificially, gelatine and sugar being the main constituents. A tablet of jelly weighs approximately 5 ounces. When water is added, the substance is usually sufficient to provide 1 pint of jelly which, when poured into moulds and cooled, retains the shape of the container. Table jellies generally contain some 11 per cent. gelatine, 63 to 70 per cent. sugar, while the moisture content is approximately 20 per cent. of the whole. A small quantity of citric acid, colouring and flavouring matters form the remaining constituents. The soluble solids content should not be less than 72 per cent. by weight. Jelly powders, which are granular in appearance, are produced by dehydration of the jelly liquid. They contain very little moisture, the gelatine content varying between 15 and 20 per cent. The percentage of sugar should not be less than 84 per cent. ; citric acid together with colouring and flavouring matters are present. *Table jelly compounds*, which consist of gelatine or other jelly-forming constituents and sugar, are made to be mixed with milk to produce a delectable table sweet. Their sugar content must not be less than 50 per cent., while the starch content, if any, should be limited to 20 per cent. by weight. Jellies of both types are packed or wrapped in waxed paper and are contained in cardboard boxes. The sweetening agent generally consists of mixed sugar and glucose or invert sugar. Only the highest-quality gelatine should be used. Sulphites should not be present other than those contained in the constituent gelatine or sugar. Colouring agents such as caramel, cochineal or saffron are most suitable, although aniline dyes are sometimes used.

Sugar Confectionery

The manufacture of sugar confectionery has reached enormous proportions in this country, the consumption of sweets and chocolates being limited only by the availability of raw materials. The prime ingredient of sugar confectionery is cane or beet sugar, although honey, molasses and syrup have been used in the manufacture of low-grade sweets. These latter materials are now being superseded by glucose in a highly-purified form, or by corn syrup, which contains dextrins, maltose and dextrose. Invert sugar and sweetened condensed milk are also extensively used ; lactose is also employed to a lesser degree. Other ingredients, which vary in accordance with the article produced, are chocolate, starch, butter or margarine, cocoa butter, malt, gelatine, gums of various types, fruit juices and flavourings, dried fruits, coconut, salt, molasses and other flavouring and colouring materials. Some sweets are soft, others are firm ; others must be hard and brittle according to popular demand.

Hard-boiled sweets are solid solutions of sugar to which colouring or flavouring materials have been added. Water is added to the mixture when production begins to assist in heating and to secure uniformity in the mass.

The moisture is boiled off in a vacuum pan until only some 1 per cent. moisture remains. Colouring matter is added when the product is ready to be worked. The volatile flavouring substances, such as essential oils, are combined with the sugar when boiling has been completed. Synthetic flavouring materials are often used in the cheaper varieties of sweets. Clear sweets are produced but, as the result of kneading or pulling when soft, air is entrapped so that the material becomes opaque. Various types of fillings and coverings may be incorporated. The final product is usually moulded or cut into desired sizes, the better grades being individually wrapped. *Caramels* are manufactured for chewing purposes. When commercially produced, milk, cream, evaporated, condensed or dried milk and butter may be added to invert or cane sugar. Cocoa butter is sometimes used to obtain the desired consistency without introducing changes in flavour. The mixture may be homogenised before being heated, after which it is cooled, cut into cubes and wrapped. *Marshmallow products* are lighter in character than those already mentioned. The contained sugar is heated with water and mixed with a solution of gelatine, gum or albumen in warm water. Air is incorporated by beating, after which the mixture is run into starch moulds, which provide a dry surface and the required shape. The moulding starch should be dry and sterile. Marshmallows tend to incorporate moisture. Proper storage is therefore essential. High temperatures cause them to become soft, while they may become dry and brittle under cold-storage conditions. Marshmallows are packed in moisture-proof containers and are sometimes coated with chocolate.

Various types of *gums* are produced by boiling sugar and starch in water, the starch becoming gum-like in consistency. The mass is constantly stirred until the required consistency has been reached. The colouring and flavouring agents are incorporated after boiling. The mixture is then run into starch moulds, after which it is brushed and sifted to eliminate excess starch. The gums are next rolled in sugar or glazed with sugar solution. This coating protects the gum from the effects of humidity and temperature changes. *Lozenges* are made by exerting high pressure on ground sugar which contains a small quantity of water until a dough-like consistency results. The flavouring or colouring agents are then added, although they may be added with the binder, if this is used. Most lozenges are of the medicinal type. *Chewing gum* is a mixture of sugar, corn syrup, chicle and crude gums, usually flavoured with peppermint or spearmint. Chewing gum may also be coated with sugar, which may be flavoured.

Fondants are produced by heating a mixture of sugar and water until a super-saturated solution is produced. This is cooled quickly and beaten to incorporate air into the mixture, which forms a cream. Crystals from a previous batch are incorporated into this mixture during the heating process to accelerate crystallisation of the sugar. The fondant cream stiffens within a few minutes but is allowed to stand for a short period until it tends to soften. It is next melted. A heated solution of sugar is added, the mixture being stirred. It is then run into starch moulds and allowed to cool. Corn starch containing a small quantity of mineral oil is used for all sugar confectionery moulds, being able to absorb moisture from the heated mass. Poor-quality starch, together with improper handling and high moisture content of the moulds, favours infection by yeasts and moulds. *Cream centres* for chocolates are produced in a similar manner but are of softer consistency. The hard fondant used for coating or dipping usually contains a small quantity of fruit acid or invertase. This enzyme inverts the sugar and changes the original firm texture into a creamy mass.

Chocolate is made in slabs or in blocks, the sweet variety containing chocolate liquor, which is a rich dark fluid, 10 to 30 per cent. cocoa butter and 40 to 65 per cent. sugar. Bitter chocolate contains 15 to 20 per cent. sugar and 15 per cent. cocoa butter. Milk powder or other concentrated forms of milk are added to sugar to produce milk chocolate, the mixture being concentrated under vacuum to a semi-soft consistency. Chocolate liquor is then added, the mass being dried and ground to form a coarse powder. Sufficient cocoa butter is incorporated with the powder to yield a paste, after which it is cooled and ground for several days. The mass is then moulded into cakes and bars, which are wrapped for sale. Nuts or dried fruits are added prior to moulding, the moulds being filled and cooled at low temperature. Chocolates having different types of centres are made by coating the filling materials with milk, bitter or plain chocolate. Milk-chocolate coatings have a rather low melting point, due to the presence of milk fat. Lecithin is sometimes added to chocolate used for this purpose to facilitate handling. There is no chemical standard for chocolate. While some chocolate is of high quality, a considerable quantity of low-grade chocolate is manufactured. Such chocolate has a starchy or gritty taste and a greyish or bluish-grey bloom. Chocolate may be infested with maggots, nut chocolate being most often affected. Infection by maggots renders the chocolate unfit for human consumption.

Most sweets and chocolates produced to-day are subject to some form of *packaging*. Boiled and similar types of sweets are usually wrapped and packed in tinned- or enamelled-metal boxes or glass jars, although cardboard containers are also used. Wrapping materials usually consist of waxed paper, transparent cellulose, metal foils, glassine and comparable substances. Wrappers afford protection against dust, dirt, insects and handling during sale. They also obviate undesirable moisture changes in the finished article.

Hygienic Aspects of Chocolate and Sweet Production

As chocolates and sweets are not subjected to any form of heat treatment after production, conditions maintained during manufacture are very important. The premises should be free from all types of insects or vermin. The quality of the materials used is particularly important. Constituent materials should be the best available and should be stored under suitable conditions. When glucose is used, its quality and method of production are of special significance. If the glucose has been prepared from acid containing arsenical impurity, serious illness may result. Many types of sweets are subject to handling by the workers, some chocolate-coated varieties being hand-dipped. Handling is also an essential part of the packing operations. For this reason all chocolates and sweets should be wrapped to afford protection prior to and during sale. Intestinal organisms can survive for lengthy periods in various types of sugar confectionery although their numbers decrease during storage. In view of this, the health of personnel is important and should not be overlooked. Scrupulous cleanliness of plant, apparatus and utensils is vital and must be constantly maintained.

CHAPTER XXI

CEREALS AND CEREAL PRODUCTS

Grains such as wheat, oats, maize, barley and rye, together with rice, provide the basic cereal foods. Some are ground into flour, while others are used in the form of whole grains or otherwise prepared for consumption. During recent years many have been produced in the form of flakes or otherwise treated to render them appetising as breakfast foods. All cereal products contain starch. Other starchy substances, which are not prepared from grain but from roots, include arrowroot, sago and tapioca. Our diet would be deficient if we were unable to obtain a sufficient quota of cereal foods in some form. Indeed, shortages lead to famine. Thus, in rice-consuming countries, where rice is the staple food, the failure of the rice crop is followed by misery and often death for vast numbers of people. Cereals in one form or another provide us with one of our staple foods, possibly the most important of the numerous types of food available.

Wheat

Of all the cereals available wheat is perhaps the most important to the Western world, constituting as it does the source of wheat flour, from which our bread is produced. The wheat plant will develop in regions where there are wide extremes of temperature and where rainfall is low, but requires sunny, warm weather if it is to mature properly and be free from the fungus diseases and rust favoured by damp conditions. Whilst wheat is grown in this country to a greater extent than was formerly the case, the bulk of our requirements must be imported from abroad, chiefly from the American continent and from the grain-growing regions of Eastern Europe. During its growth wheat is subject to the action of various blights and fungi, which result in low yields and injure the resultant grain. These diseases, which are favoured by warm damp weather, are controlled by fungicides, seed treatment and the use of resistant varieties. Insect pests also cause great damage to the crop if not controlled, the Hessian fly and cinch bug being notable in this respect. When ripe, the wheat is harvested and finally threshed, a process which cleans the seed. Wheat must be suitably stored, protection from moisture and extremes of temperature being essential. Wheat kernels undergo certain respiratory processes during storage, the rate of respiration increasing when the wheat is damp. The temperature is substantially raised. Warm damp conditions favour the growth of micro-organisms on the wheat kernels during storage, lowering the quality. While a small quantity of moisture is normally found in wheat, if the grain becomes overheated it is likely to produce flour of poor baking quality. A disease known as *bunt* (*Uredo fœtida*), due to a fungus, affects the wheat in some cases. The infected kernels become filled with a dark-brownish powder which is difficult to separate from the sound wheat kernels, as it is greasy to touch, while possessing a disgusting fish-like odour. Bread produced from such flour will have a bitter taste and may be the cause of diarrhœa. Some of these balls are soft and will break during the normal handling processes. They release dark-coloured spores which give the grain a black appearance. In other cases they may be hard and appear little different from good-quality wheat. Fungicides are used on the seed wheat to prevent infestation of the crop. *Smut* (*Uredo segetum*), which also attacks wheat, develops into a finer powder than does bunt and gives the bread a disagreeable taste, although its effect upon the consumer is not known. *Moulds* will also affect wheat when it is stored in a warm, damp place. Each grain of wheat has (*a*) an outer protective covering, which is known as *bran* and contains cellulose and mineral matter ; (*b*) the kernel, or endosperm, which is a cellulose container filled with starch ; and (*c*) the embryo, or germ, which is rich in fat and protein.

Although threshing removes large quantities of unwanted material from the grain, *cleaning* is necessary to remove seeds and other waste materials which are mixed with it. The effects of the admixture of foreign seeds is to reduce the value of the wheat to the baker, as such unwanted additions will change both the texture and colour of the final bread and produce unwanted flavours or odours. The seeds are shaken or sieved in a suitable air current, the separation of the wheat kernels from the remaining materials being due to difference in specific gravity, length and shape. Special separators are employed to remove large seeds when these are present. When the wheat is infected with bunt, the grain is either washed or scoured with slaked lime. After cleaning and during storage wheat may be subject to the depredations of grain moths, grain beetles, flour mites and weevils. In such cases it is usual to fumigate the affected grain in an airtight bin at temperatures between 75° F. and 95° F. Fumigants which are heavier than air are used, so that the gases emitted will sink down through the grain to destroy the eggs, grubs and adult insects. Sulphur dioxide was formerly employed for this purpose but has now been replaced by other gases. Carbon disulphide is efficient but induces fire risks when used alone, although these may be limited by the addition of carbon tetrachloride. Ethylene oxide to which carbon dioxide has been mixed in the ration of 1 : 7 may be used (2 lb. per 1,000 cubic feet) and is very efficient, as is hydrogen cyanide. This latter gas cannot be used for the treatment of seed grains since it affects their subsequent germination, while it is extremely dangerous to human beings and requires expert handling. Chlorpicrin may also be used. This gas is often mixed with hydrogen cyanide to act as a warning gas, as it possesses a lachrymatory effect. None of the chemicals used cause objectionable odours in the flour or affect the baking characteristics. Heating the grain to temperatures between 125° F. and 140° F. will eradicate infestation, but this process drives off moisture and causes loss in weight. Cooling will temporarily inhibit insecticidal activities. A return to higher temperatures favours renewed attacks.

In order to produce the flour required for human consumption *milling* is necessary. Wheat and other cereal grains consist mainly of carbohydrate. The protein content is most important from the nutritional aspect, however, as this substance enables the carbon dioxide gas produced when dough made from flour is fermented to be absorbed. This leavens the loaf and renders it more edible and tasty. Each seed possesses an aleurone layer, found directly under the husk, or bran, together with the centre portion of the kernel, which consists of gluten and starch. The cells of this layer contain fat, mineral matter and protein and constitute some 8 per cent. of the kernel. They are removed along with the bran during the milling process. When the aleurone layer is removed, the remainder is reasonably friable and easily ground by passing through rollers during the milling process. The germ, which contains most of the fat, together with the sugar and non-glutenous protein, is eliminated by the milling process, as the fat tends to produce undesirable flavours and discolorations in the flour. A further cleaning is given to the wheat before it is milled. This is carried out in separators, which make use of agitating screens and forced-air currents, followed by disc separators. The wheat is then brushed or scoured to remove any dirt which remains in the crease in the seeds. If it is desired to produce a blended flour, several varieties of wheat may be mixed at this stage. Alternatively the flour may be mixed with other varieties after milling. It is usual to condition wheat prior to milling in order to toughen the bran, or husk, so that the flour is more easily separated from it. A certain amount of water is added for this purpose, the quantity required depending upon the hardness of the wheat kernels, the size of the grain and its initial moisture content. The moisture content is increased by passing the wheat through damp chambers, mixing with other wet wheat or by means of a fine spray. In some cases the temperature of the wheat is raised before the tempering process is begun.

The wheat is next passed through a *breaking* machine which has corrugated or grooved steel rollers rotating in opposite directions, one roller travelling two and a half times more rapidly than the other. This process separates the large particles of bran as it crushes the kernels. The process may be repeated up to eight times, although five treatments are usually sufficient. The coarse fragments which remain after the final rolling constitute the *bran*. This is used to some extent as a breakfast food, but mainly for cattle feed. Bran is dusted to remove any flour before it is removed to storage bins. Unless very finely ground, bran exerts an irritant effect upon the intestinal tract and is apt to be indigestible. The material obtained from this treatment is termed "*middlings*" and is the source of flour, although in that condition it is of inferior quality. The "middlings" are sifted to remove extraneous particles from the flour. This process is combined with the application of suitable air currents, controlled in such a way that as much bran as desired can be removed. *Reduction* of the middlings is necessary to convert the material into flour. Further grinding is given, smooth rollers being used, one of which revolves one and a half times as fast as the other. These rollers are more closely set than the breaking rollers. After each reduction treatment the crushed material is separated by means of sieves, the particles being graded according to size and conveyed to the rollers, which are set close together, pressure being applied during the later stages. During this process the germ of the wheat kernel, which has a relatively high fat content, is removed. This substance is used to some extent for human vitamin foods, as it contains fair amounts of vitamins B_1, E and G, together with a small quantity of vitamin A. If the germ content is not reduced the keeping quality of the resultant flour will be poor, whilst the colour may be darkened owing to the presence of enzymes. Materials which contain large quantities of bran may be passed through revolving horizontal cylinders, or "bolters." These have mechanical beaters, which force the finer particles through the silk cloth which covers the cylinders.

The colour of flour is never a pure white owing to the yellow carotinoid pigments contained in the wheat. In order to obtain the whitest possible flour, *bleaching* is frequently carried out. The colour may also be darkened by the inclusion of bran particles. The bleaching treatment is in effect an oxidising process, the carotin being bleached by oxidation. If the separate particles of flour were exposed to the atmosphere the substance would quickly bleach, especially if the direct rays of the sun could have access to it. Such changes would, however, be too slow for commercial practice. For that reason either chlorine dioxide, nitrogen peroxide, nitrosyl chloride, mixtures of chlorine and nitrosyl chloride, nitrogen trichloride (Agene) and organic peroxides, such as benzyl peroxide, are used together with a number of patent bleaching compounds. The Medical Research Council has indicated that nitrogen trichloride provides a potential hazard to the consumer, although there is no evidence at present available to show that human health may in any way be injured. If a gaseous bleaching agent is employed, it is mixed with air and brought into intimate contact with the flour particles in an agitator or by exposure of a thin film of flour to the gas. Solid bleaches must be thoroughly mixed with the flour in a mixing machine. Storage of flour will cause it to whiten, but chemical agents are invariably used to accelerate the process and to reduce storage time. The addition of enzymatic material produced from soya beans will increase the whiteness of bread. This material is added after the dough has been mixed and acts during fermentation. If this method were the normal practice, chemical bleaches would become unnecessary. Bleaching does not improve the quality of the flour. A bluish-white appearance and bitter taste indicate excessive treatment.

After bleaching is complete *grading* is usually carried out. Grading is essential when different varieties of flour are required. Grading is an important operation, as many different types of flour are handled at the flour mill. Both ordinary and wheat flours are produced, divisible into a number of grades according to choice. The highest percentage of white flour obtained from wheat on a commercial scale is between 70 and 72 per cent. Flours of higher extraction contain a proportion of the bran materials. Wholemeal flour is the result of 100 per cent. extraction from clean wheat without dilution, while wheatmeal flour is the name given to flour where the extraction is over 85 per cent. During and since the War the extraction rate has been increased, so that the pure white flour of pre-War days is no longer available. The present extraction rate for flour is 80 per cent. Wholemeal and wheatmeal flours are not completely separated from the bran and contain a proportion of this material. These types of flour are favoured by certain dieticians who hold the opinion that far too much food value is lost when all the bran is removed. Patent brown flours are produced by the admixture of white flour to which the ground germ, previously treated with steam to destroy its fermenting properties and prevent the fat from becoming rancid, is added. In some cases the mineral salts and nitrogen are extracted from the bran by boiling under pressure and are thereafter added to the flour. Some wholemeal flours are mixed with malt flour or malt extract, while other flours are fortified by the addition of vitamin B_1 (aneurine). Wheat flour contains from 8 to 15 per cent. gluten and, along with rye flour, can be used for bread making. The flours produced from grinding barley, oats and rice do not contain this substance and cannot therefore be made into bread. Good flour should be faintly yellowish-white in colour, be free from odour and possess no acidity. It should be smooth to the touch, heavy and when squeezed in the hand should retain its shape. Old or spoiled flour usually gives a sour or acid reaction and is generally yellow in colour. It may be gritty, lumpy and sticky or moist.

Chemical examination of flour is mainly directed towards the estimation of any additions, adulterations and the presence of bleaches and improvers. Flour is rarely adulterated in this country, while the addition of flours produced from other grains is easily detected by microscopical examination. *Alum* has been used to increase the whiteness and apparent quality of inferior flour ; *salt* is also added in the ratio of 5 lb. per sack of 280 lb. to prevent rancidity developing in flour which contains the germ of wheat. *Improvers* are substances added to flour in an attempt to accelerate the natural ageing process, flour which is several weeks old producing a more satisfactory loaf. Improvers increase the strength of flour by permitting it to take up more water. They produce a moister bread, while some possess bleaching properties which improve the appearance of inferior flours. The common improvers used are acid calcium phosphate, di-calcium phosphate, potassium or ammonium persulphate and potassium bromate. Some of the bleaching agents also act as improvers. Flour is occasionally fortified by the addition of calcium carbonate, a few ounces per sack of 280 lb. being added, the quantity varying from 7 to 14 ounces according to the type of flour. *Self-raising flour* may contain a variety of chemicals of the types found in baking powders, such as tartaric acid, cream of tartar or acid calcium phosphate. This ensures the production of gas during the dough-fermentation process and during baking. The correct strength of flour is also important. The fluorine content of self-raising flour must not exceed 8 parts per million, while not more than 14 per cent. of moisture should be present. The substance should yield not less than 0·4 per cent. of available carbon dioxide.

Bread

Bread is probably the most universally-consumed food in the world, being eaten by almost everyone at some time or another, irrespective of race Originally produced domestically and then in small hand-operated bakeries, of which a large number still exist, the manufacture of bread has now become a highly-developed and mechanised industry. This has resulted in greater uniformity and quality in the product and more hygienic handling generally. The raw materials used, which include flour, salt, water and yeast, must be of the highest quality. All ingredients must be weighed. For special types of bread, milk, mineral salts, malt extract, sugar and shortening may be utilised. The main ingredient is, of course, flour. The quality of this latter material depends upon the type of wheat from which it has been produced, or upon the blend of flour from various types of wheat. The primary dough used for bread baking, which is produced from flour, water and other ingredients, becomes a colloidal mass consisting of starch and protein, each particle being covered by a thin film of water. The addition of shortening agents causes fat adsorption and reduces the degree of cohesion between the particles. The reactions which occur in the dough are dependent upon the enzymes present in the flour and yeast, the size and character of the starch and protein particles, temperature conditions, pH, the fermentation of the yeast, the presence of inorganic salts and the sugar content. If the ingredients were merely mixed the bread would be disagreeable, heavy, soggy and highly unpalatable. The dough must ferment and rise properly, while the yeast must be thoroughly incorporated so that fermentation, with the evolution of large quantities of carbon dioxide, proceeds. This latter gas is trapped in the glutinous dough, so that the entire mass is lightened. Should carbon dioxide escape, a heavy, compact but tough bread would result. For this reason oat flour and barley flour are not suitable for bread making, as they do not contain gluten, which enables the carbon dioxide to be retained. Further, some types of wheat flour possess a lower gluten content than do others, so that several types may have to be blended before a suitable bread-making flour is obtained.

Before dealing with the actual production of bread its various constituents may be briefly considered. Apart from flour, the major ingredient is *yeast*. This substance (*Saccharomyces cerevisiæ*) is a culture of small single-celled plants which possess the power of converting sugars into carbon dioxide and ethyl alcohol. The baker is most interested in its gas production, since the carbon dioxide lightens and leavens the loaves, rendering them palatable and appetising. The alcohol is of little interest, as this is driven out of the bread during the baking process. Bakers' yeast consists of cultures which possess favourable fermentation properties but which do not spoil but rather improve the flavour of the bread. Bakers' yeast is a modified culture of distillers' yeast. It is compressed into small packages and it should be as fresh as possible when used, so that it retains its vigour and will produce substantial quantities of carbon dioxide in order than the dough may rise quickly. The speed of fermentation is regulated by the quantity of yeast used, although the temperature of fermentation is also important. When yeast fermentation is active, there is less likelihood of undesirable bacterial fermentation taking place. Yeast secretes enzymes which exert a beneficial action upon the gluten in the flour.

The leavening of bread without the use of yeast may be accomplished by means of *baking powders*, which are chemical agents of various types. These bring about the rapid evolution of gas in the dough. Baking powders are mainly used in the production of cakes and pastry. Numerous varieties of proprietary baking powders are obtainable, falling into two categories, i.e. quick acting and slow acting. They may be composed of potassium tartrate (cream of tartar), which contains a proportion of tartaric acid, and liberate their total carbon dioxide content at normal temperatures. Powders of the acid calcium phosphate or sodium acid pyrophosphate types do not free all their contained gas until the dough reaches the oven. Other types may be mixtures of sodium aluminum sulphate and calcium phosphate. Maize starch or rice flour are generally added as fillers. These materials are also useful in coating the chemical particles to prevent premature reaction. Citric acid is also used, whilst in some countries compounds of aluminium are employed. In this country, however, the use of aluminium compounds has been the subject of prosecutions. The proportions of the various compositional chemicals determine when the evolution of the carbon dioxide gas takes place. Those powders which evolve their gases at oven temperatures are most preferred. Baking powders should yield not less than 8 per cent. available carbon dioxide and not more than 1·5 per cent. of residual carbon dioxide. In some cases the dough may be kneaded with water charged with carbonic acid gas under pressure to produce what is known as aerated bread. Baking powders must not contain more than 100 parts per million of fluorine where the article yields less than 15 per cent. of available carbon dioxide. If the yield of carbon dioxide is in excess of 15 per cent., up to 133 parts per million of fluorine may be present.

In malt bread the *malt extract* contains useful enzymes which convert starch into maltose and dextrin and provide food for the yeast. This substance also sweetens the dough and colours the crust. If *cane sugar*, or sucrose, is employed, this forms the main sugar on which the yeast works, being added for this purpose as well as for sweetening the bread and improving the flavour. Not more than 1·5 to 3 per cent. is normally used. *Improvers* are often added in small quantities to act as stimulants for the yeast and to cause rapid evolution of gas. They are sometimes combined with the bleaching agent used in the production of flour. These chemicals, which have already received mention on p. 314, are used in relatively small quantities. *Salt* is also added to bread. Salt serves the dual purpose of assisting in the production of suitable flavour and, to some extent, of controlling fermentation of the dough. Salt also imparts strength and binding power to the gluten contained in the flour. *Shortening* may be added to improve the palatability of the final product, to improve the appearance and keeping qualities of the bread and to increase food value. Butter, lard, hydrogenated vegetable oils and beef stearin are used for this purpose and to reduce the toughness of the final product. These commodities are particularly important in pastry making. If used in excess, shortening interferes with yeast fermentation. *Water* is an important ingredient and should be as pure as that available for drinking purposes. Hard water is particularly suitable for bread making as its contained salts are useful for yeast development. Alkaline water tends to affect the gluten, whilst chlorinated water exerts a deleterious effect upon the yeast fermentation and upon the final quality of the bread. The quantity of water used depends upon the absorption properties of the dough. *Milk* is sometimes used in place of or in addition to water. It adds solids to the dough besides acting as a moistening agent which strengthens the gluten. Milk concentrates, either in liquid or powdered form, are often used. They improve the texture, flavour, quality and food value, whilst the yield of bread is also said to be increased. The use of milk requires an increase in the amount of water employed to prevent binding of the dough. This would impair the final quality. The solids content is not reduced by this addition owing to the increased milk solids which are added.

The *manufacture* of bread comprises a number of different operations. The flour is often sifted to remove extraneous matter and weighed. Sifting aerates the material and ensures the breakdown of any lumps which may be present, tending to produce a flour of a more uniform character. In the *straight-dough method* all the ingredients are mixed together so that processing continues in a uniform manner. The water which is added should be of suitable temperature for fermentation, a portion of the liquid being used for mixing with the yeast. If special breads are being made, the extra ingredients receive an initial mixing, after which half of the flour is added, the resulting mass being again mixed. The yeast solution and the remainder of the flour are then incorporated and the whole mixed. If any shortening is required, this substance is added and the mixing continued. The temperature should be maintained so that the dough comes from the mixer at temperatures between 76° F. and 79° F. *Sponge dough* involves the mixing of some of the ingredients to form a sponge or active culture. After being allowed to rise for a short time the remainder of the ingredients are added to the mixture. This method saves time and labour, while it is less open to error. Over-mixing will injure the gluten content. Sticky, weak dough will result, the final loaf having poor grain, volume and texture. Under-mixing prevents complete uniformity of the ingredients and causes irregularities in the fermentation and conditioning of the dough. When mixing is complete, the dough is placed in greased *fermentation* troughs to condition. The temperature and humidity of the room in which the process is carried out are important factors. The temperature should be approximately 80° F. ; the humidity should be such as to prevent loss of moisture from the dough by evaporation. If this precaution is neglected the external surfaces of the dough will harden. During the process the dough should be folded and turned to secure a more uniform product. When conditioning is complete, the dough is cut either by hand or machine according to the size of loaf required. Extra dough is allowed in order that the finished article may be the correct weight in spite of any shrinkage during baking operations. In this country no loaf is allowed to be sold unless its net weight is 1 lb. or an integral number of pounds. The usual sizes of loaves are 1 lb. and 2 lb., although in some cases 4-lb. loaves are produced. This requirement does not apply to fancy breads, while in Scotland pan loaves may be sold at a net weight of $1\frac{3}{4}$ lb. if the weight is clearly indicated. When the dough is cut it is impossible to prevent the escape of some of the contained carbon dioxide. The separate portions are therefore rounded or kneaded to provide a protective film which prevents any further loss of gas. The dough is then given a brief proofing, being allowed to rise for a short period either on sliding trays or on moving belts which are dusted with flour to prevent dough adhering to the equipment. The pieces of dough are then kneaded once more, dusted with flour and placed into lightly-greased tins of suitable size, the seams of the dough being set downwards. All baking-tins should be kept clean and free from dust, burnt crumbs and other residues.

The tins and their contents are placed on racks and removed to a proofing room so that the loaves may rise and increase in volume, rendering the final product light. Temperature and humidity are important during *proofing*. The humidity should be between 80 and 85 per cent., with the temperature in the region of 90° F. to 95° F., automatic control being used in modern bakeries for this purpose. The proofing process occupies between thirty to sixty minutes. Underproofed dough will result in a heavy, soggy loaf, while if carried to excess the gluten will be weakened and the loaf will distort when in the oven. Excessive temperatures and lengthy treatment may result in the development of certain types of bacteria which are present in the flour and are responsible for sourness in the bread. Condensation of moisture on the ceiling should be prevented so that droplets of water do not fall on the loaves, causing the final product to exhibit a poor appearance. Care must also be taken to prevent any collapse of the dough during its removal to the oven.

Two main types of oven are employed for *baking*, the pans either remaining stationary or travelling through the apparatus by means of a conveyor or belt. Ovens may be either internally heated as in the case of the side-flue type, or externally heated as in the steam tube oven. Travelling ovens are usually oil fired. Several types of fuel are used, coal and coke being more generally employed, although oil is used in the larger bakeries. The heat generated should be circulated as evenly as possible. The optimum temperature should be in the region of 400° F. The heat applied causes a slight caramelisation of the sugar present in the flour, giving the loaf its usual light brown colour, dextrinisation of the starch taking place and a crust being formed on the outer surfaces. The internal temperature of the loaf rarely exceeds 212° F. The application of heat to the loaf entering the oven causes it to expand to twice its original size. Half to one hour is usually required to complete the baking process, according to the size of the loaf and provided a suitable temperature is maintained. With modern mechanical ovens provided with automatic temperature controls, the bread is delivered at the exit end properly cooked. Spoilage is virtually impossible. After baking has been completed, *cooling* is required, the loaves being removed from their containers and placed on trays for this purpose.

In any progressive community the *wrapping of bread* should be regarded as highly desirable, even having regard to the fact that bread is seldom associated with food poisoning. In many foreign countries this process is compulsory. When consideration is given to the way bread is normally handled, particularly by those delivering the product to the consumers, bread-wrapping as a means of protecting loaves against contamination should be accepted as normal practice. Bakery employees rarely handle bread with care, the roundsman's hands are often grimy, loaves are on occasion dropped on to the dirty streets and are frequently left on doorsteps in the absence of occupiers. Prior to the War many bakery firms were supplying nothing but wrapped loaves. The paper shortage produced by war-time restrictions caused this desirable practice to cease by Government order. The wrapping of bread is once again permitted and, as adoptive powers are provided to enforce compulsory wrapping, local authorities should take steps to enforce this practice. Apart from the hygienic or even æsthetic aspect, the wrapping of bread has psychological value, since it clearly indicates the need for care in protecting foodstuffs from contamination. Bread cannot be wrapped while hot, otherwise it would become mouldy on the external surfaces, while ropiness might develop internally. A loaf wrapped while hot would certainly possess a soft crust owing to moisture escaping from the substance as it cools. Many *mould spores* can be isolated from the air of bakeries. These spores may be also present on the wrapping papers even when these are of the highest quality. If the loaf has a soft crust due to wrapping in a warm condition, the spores may rapidly develop into white, blue or green moulds. These also affect bread when it is stored in warm, moist air.

Bread, whether wrapped or unwrapped, should always be stored under cool conditions. Red or violet streaks sometimes develop in bread. These are not usually noticeable until the loaf is cut. This condition is due to organisms of the *B. prodigiosus* type present in the bakery. As an aid to clean air in the premises and in order to reduce or prevent the number of spores present, air conditioning should always be considered necessary in premises of any size. Wrapping papers should be carefully protected from contamination until they are used. The loaves should be allowed to cool after baking until their internal temperatures are below 95° F. In some bakeries artificial cooling is adopted to ensure that the loaves can be cooled and wrapped as quickly as possible after leaving the ovens. *Souring* is a common defect and is produced by *B. lacticus*, whilst *B. butyricus* may be responsible for the production of butyric acid. Mould development may also occur. *Ropiness* develops following the growth of certain types of bacteria, particularly spore-formers such as *Bacillus mesentericus*. The spores may be present in the flour, in water or in other raw materials. They are also present in dust and air. As the spores are strongly heat-resistant, they may survive the baking process in the interior of the loaf. When pressed between the fingers and pulled out, a crumb of bread infected in this manner forms long threads ; a peculiar odour is also noticeable. The bread affected possesses an offensive taste, may be discoloured and has a viscous or sticky crumb. This is one of the most serious conditions met with in the bakery industry. In order to avoid such an occurrence, excessive temperatures during fermentation and proofing should be avoided. Care in allowing the dough to rise for the correct period is also essential. The bread should be cooled as rapidly as possible and should always be stored under dry conditions. Finally, absolute cleanliness in the bakery is necessary if this difficulty is to be avoided. Some bakers incorporate a small quantity of acetic acid in bread, particularly during warm weather, since acidity will inhibit the development of spore-forming organisms.

While bread should be cooled as rapidly as possible, ultra-rapid *cooling* after it leaves the oven should be carefully avoided. If this precaution is neglected, cracks will develop in the crust. A certain amount of humidity is also necessary to prevent the loaves losing too much moisture. Excessive humidity has certain disadvantages, as already indicated. It is usual to leave the bread to cool in the baking room for some fifteen minutes before it is removed for final cooling. The cooling room may have to be slightly heated during the winter months ; during warm weather it may have to be cooled. When loaves are to be wrapped, artificial cooling is finally employed, a blast of chilled air being sprayed on to the loaves as they pass on a conveyor belt to the wrapping machines. The interior temperature of the loaves should be below 95° F. when they are wrapped.

Bread is judged by its colour, volume as compared to weight and by the shape of the loaf. The crust should be judged by its bloom, colour, taste, softness, thickness and digestibility. In turn, these qualities depend upon the quality and quantities of the original ingredients and upon the correctness of the processing methods. The properties of the interior of the loaf are important in forming judgment as to its quality. These properties are colour, grain, texture, velvetiness together with aroma, digestibility, flavour and palatability. The ingredients should be standardised as rigidly as possible if a suitable final product is to be obtained. Since the flour is most likely to vary in quality, it should be the subject of careful tests before any new batch is used. It should always be remembered, however, that many different types of bread are produced and that the qualities set out above will vary with the type under consideration.

The *chemical examination* of bread deals mainly with its moisture and ash content and with the presence of copper sulphate, which may be due to the original wheat seeds having been steeped in copper sulphate solution to act as a fungicide before they are sown. Examination for the presence of alum and foreign starches is also carried out, while the employment of suitable bleaching materials can be checked in this way. Potato starch has sometimes been added to flour used for bread making. Rye flour has also been found.

Flour Paste Products

A number of products made into pastes from flour and finally moulded into various forms find a ready sale. In some countries they form an important article of diet. One of the basic materials used for the manufacture of these articles is *semolina*. This is produced from "durum" wheats, the round particles of which are flinty and translucent. The substance is coarsely ground and carefully purified into coarse particles which are of similar size. These are creamy-yellow in colour and should be free from flour or bran. Semolina is also used for the production of table desserts and in puddings. *Farina* is another basic ingredient and is much similar to semolina, being obtained from other varieties of hard wheat. The main product of the paste type is *macaroni*. Flour, salt and water are mixed to form a very stiff dough, which, after kneading for a short period, is rolled into sheets or moulded by means of a press, being retained at a temperature of 100° F. so that its plastic condition is maintained. The dough is forced through apertures under pressures which vary from 2,000 to 4,000 lb. per square inch. The dimensions of the apertures decide the shape and diameter of the product. The macaroni strands are usually dried in air-conditioned rooms so that temperature and humidity can be carefully controlled. They are supported on racks for this purpose. If cut into small pieces, trays are employed for drying purposes. In Italy macaroni is dried in the open air, but exposure in this way may result in contamination. The final moisture content of the product should not exceed 13 per cent. of the whole. In this condition the material can be stored for long periods under cool conditions. Macaroni is usually hard, brittle although somewhat elastic and yellowish in colour. When in long pieces or strands, it should bend without breaking. The strands are usually cut into suitable lengths and packed. If the quality is good, boiling will double the size of the macaroni strands and retain the recognised tubular shape. Eggs are sometimes used to impart a yellow colour to the dough ; artificial colouring matters may be employed in the production of an inferior article. *Spaghetti*, *vermicelli* and *noodles* are produced in the same way but vary in shape and thickness. During the War, macaroni was used fairly widely for the manufacture of milk puddings in the absence of rice. Spaghetti in tomato sauce has been canned for many years and is a popular dish. These materials are sometimes found to be infested with small weevils' eggs which may be present in the original flour.

Pastry and Flour Confectionery

Large quantities of flour together with eggs and sugar are used annually for the production of cakes ; pastries of various types are made from flour and fat, both types of articles forming popular items of diet. Many substitutes are used in the manufacture of cakes. Artificial cream, liquid and dried eggs, egg powders and baking powder are utilised, while sodium and potassium carbonates, ammonium carbonate and alum, with bicarbonate of soda and tartrates, are used for aeration purposes in the cheaper grades. The flavouring matter used include lemon, vanilla and ginger essences together with almond and orange oils and essences. Cochineal is the principal colouring agent, but saffron (yellow) and chlorophyll (green) are also used, metallic and coal-tar dyes being prohibited. Mineral oil in excess of 0·2 per cent. per 100 parts by weight must not be present in cakes and prosecutions have followed discovery of excesses in this direction. Its presence in this small proportion is only permissible when it is the result of the mixture coming into contact with some surface on which it has been used as a greasing agent. This step has been taken to prevent the use of such oil, and particularly liquid paraffin, which attained great popularity owing to the normal fat shortage. Excess mineral oil may injuriously affect the consumer. After baking, cakes and pastries lose their heat very slowly. Protection from contamination during this process is most important. This is particularly the case when these articles are produced in small bakehouses. In these premises the products are often exposed to contamination by wind-blown dust from adjoining streets and yards. Under such conditions infection with various types of micro-organisms can scarcely be avoided.

Biscuits

The production of biscuits now forms an important part of the baking industry. Very substantial quantities of various types of biscuits are produced for sale at home and abroad each year. Biscuits form an important and nutritious part of the diet. A weak flour with a low protein content and a thin, runny gluten is made into a spongy dough which undergoes yeast fermentation, or is made into batter in which chemical leavening agents take the place of yeast. The dough should not be springy, otherwise it may tighten and creep. The viscosity should be low. The biscuits are cut into various shapes and are baked in automatic ovens, being passed through the apparatus on large trays. The fancy decorations or additions such as icing, chocolate, cream or jam are added after baking is completed. In many instances the finishing rooms are air-conditioned. The cream fillings tend to become rancid within a short time. The popularity of biscuits has been enhanced by the variety of type and design of the packages available, together with the efforts of the manufacturers to produce packing materials which are both attractive and useful. Biscuits are mainly packed in square metal tins, either loose or in wrappers. They will keep for long periods under suitable conditions. Containers must be dirt- and vermin-proof and prevent any access of moisture, since biscuits will turn mouldy if damp conditions exist. When shortening is used in their production, as in the case of shortcakes, rancidity may develop due to access of light.

Barley

Barley is an important cereal to both the brewing and distilling industries. It is subject to various forms of blight during growth and after production and has numerous uses. *Pearl barley* is the name given to pellets of the grain which have been husked and polished by mechanical abrasion. Barley which possesses large kernels is favoured for the production of this material, which is used in the constitution of soups, dressings, puddings and in the preparation of barley water. Pearl barley is sometimes faced with talc. *Pot barley* is normally manufactured from the smaller grains, the outer husk being removed. Formerly sulphur dioxide was often found in both pearl and pot barleys. This is no longer permitted. Mites of various types are sometimes found in the dusty portions. A certain amount of *barley flour* is now produced, an extraction rate of 70 per cent. being enforced. During the War this type of flour was incorporated in the flour used for bread baking in the ratio of 1 part to 5 parts of wheat flour. Barley flour does not possess sufficient gluten to be used *per se* for the production of bread, but the mixture of barley flour with ordinary wheat flour increases water absorption. The dough is less lively and shorter and the colour of the resultant bread is darker than that manufactured entirely from wheat flour. Barley flour and barley meal are also used in the constitution of certain infant and invalid foods.

The main use of barley is for malting purposes, malted grain being used for brewing, distilling and in the production of yeast for bakers. It is also employed in the manufacture of malted beverages and extracts, for malt syrup used in bakeries and confectionery establishments, for coffee substitutes, in the preparation of breakfast cereals and for pharmaceutical preparations. *Malt* is produced by the germination of the carefully cleansed and screened grains of barley which have been graded according to size. The grains should be sound in texture and colour and be plump and mellow. They should be soft and starchy in appearance when broken. Damaged, dirty or small grains should not be used. The grain is soaked in cool water for periods which vary between thirty and seventy-two hours, the kernels absorbing moisture and swelling considerably. The swollen grain is then maintained at a constant temperature in a humid atmosphere, either in special rooms or in large slowly-revolving drums, until germination takes place. The carbon dioxide content of the atmosphere must not exceed 3 per cent., otherwise the germination process will be retarded. This is achieved by suitable ventilation. The whole process occupies approximately four days. When completed, the grains begin to sprout. During this period the enzymes are elaborated, the diastatic enzymes converting the starch content into the sugars, maltose and dextrose. When the fermentation process has been completed, the grain is transferred to a kiln, where it is dried. The temperatures employed are not sufficiently high to affect the activities of the enzymes. Approximately two days are required to reduce the moisture content to approximately 5 per cent. of the whole. The malt is then screened to remove the sprouts, after which it is packed in sacks ready for the market.

Maize

Maize, or *corn* as it is termed in the United States of America, is grown mainly as a cattle food, but possesses certain uses in relation to human nutrition. Very little maize is grown in this country, as both heat and moisture are required for its satisfactory development, together with a rich soil. The corn is removed from the stalk when ripe, either by hand or by means of a special machine. The kernel is composed of the *hull*, which amounts to 5 per cent. of the whole, the *endosperm* and the *embryo*. The endosperm, which is composed chiefly of starch, constitutes more than 80 per cent. of the kernel ; the remaining portion is made up of the embryo, or germ, which has a large fat, carbohydrate and protein content. Maize also contains small amounts of vitamin A. It cannot be stored in a satisfactory manner unless its moisture content is low. The high fat content renders it particularly subject to spoilage when ground.

Maize has a number of culinary uses. It is consumed as " green corn " in its milky or sweet state, particularly in the United States of America, large quantities being canned annually for future use. It is also used in the manufacture of breakfast foods, particularly in the form of cornflakes. Increasing quantities are being produced each year for this purpose. It also forms a basic material for the manufacture of glucose and corn syrup. Preservatives are allowed in this substance in the ratio of 450 parts per million. *Pop-corn* is another familiar product which is manufactured by rapidly heating the kernels in a wire container so that the contained moisture expands and ruptures the kernels with explosive force. Pop-corn is eaten with salt, butter and molasses. *Maize meal*, or *cornflour*, is also produced for human consumption, being a highly nutritious food. The whole kernel is ground. Inclusion of the germ favours rapid deterioration of the meal unless quickly consumed. To improve the keeping quality, both the husk and germ are removed during the milling process together with a proportion of the protein and most of the fat. This is effected by treatment with alkalies. Maize flour contains no gluten, so that it cannot be used for the production of bread although it may be incorporated into various kinds of cakes. Wheat flour has been found to be adulterated with maize meal, since this latter substance is often cheaper. Very little adulteration is carried out in this country at the present time. Cornflour itself is often adulterated by the addition of sweet potato starch, while rice starch has also been sold in lieu. It forms a basic ingredient of *custard* and *blancmange powders* and of various *table desserts.* Such articles should contain 50 per cent. maize cornflour, 20 per cent. farina and 30 per cent. white wheat flour together with a trace of colouring or flavouring matters. Sulphur dioxide in the ratio of 100 parts per million may be used as a preservative. Approximately 10 parts per million may be normally present due to its mode of preparation. *Corn syrup* is largely employed by the confectionery industry, and to a certain extent for the production of jams and jellies. It is produced from the starchy matter by hydrolysis. If the process is prolonged, *corn sugar,* variously used by bakeries or by the canning industry for the production of syrups, is obtained.

Oats

Oats form a very popular human food when prepared as oatmeal or as rolled oats, various types of which are used as breakfast foods. Oats can be grown under damper conditions and in cooler climates than many other types of grain, and in districts where wheat would not ripen. Drought conditions are not suitable for their development although they will normally survive extreme changes of climate. For human consumption, oats are used chiefly in the form of breakfast cereal. Quite often extravagant claims as to the nutritive value of various types of rolled oats or other breakfast foods are made. It is doubtful, however, whether their digestibility or nutritive content is any higher than that of the old-established and cheaper oatmeal, which they have largely superseded. The gluten content is so low that oats are useless for the production of bread, although in Scotland oatcakes, or bannocks, are produced from oatmeal, which is also eaten in the form of porridge. Oat flour, for which an extraction rate of 85 per cent. is fixed, is sometimes mixed with wheat flour for bread manufacture. Its presence causes the resultant dough to be more stable but very sluggish. Oatmeal is produced when oats are ground and freed from their husks, after which the material is dried in a kiln. It becomes stale after storage for lengthy periods and has a characteristic taste. Oatmeal may contain mites and often becomes mouldy, this latter condition being detected when the meal is run through the fingers, as the mould grows in the form of long hairs.

Rice

Rice forms the staple food of approximately one-third of the world's population. It requires both warmth and an abundance of moisture during its long gestation period. To obtain the type of rice known to commerce the grain is threshed after harvesting and then milled. The grain is milled by passing between two stones, the uppermost of which revolves while the lower one remains stationary. This causes the kernels to be freed from the hulls. These are then sifted, the final product being known as *brown rice.* To obtain *unpolished rice* the material is passed between two rollers or cylinders, one of which is tapered and grooved, the other being horizontal and stationary. A portion of the bran is also removed by this treatment, the remainder being discarded during the sifting process which follows. All extraneous material is removed in this way. When *polished rice* is required the grain is allowed to run between two vertical cylinders. The inner cylinder is covered with strips of leather and revolves rapidly, rubbing or polishing the rice as it passes between this cylinder and a stationary metal cylinder. A current of air is used to maintain the rice in cool condition and to remove all dust. The polishing process is often assisted by the use of talc. French chalk may also be employed for this purpose, while a small quantity of oil may also be used to impart greater translucency to the grain. To increase its whiteness various dies, such as indigo, Prussian blue or ultramarine, are often used. Polishing removes the outer layer of each grain and destroys most of the vitamin B content. Natives of Eastern countries who consume unpolished rice do not suffer from beri-beri, a deficiency disease which affects those who consume the polished variety. *Rice flour* is produced by milling polished rice. It is largely used by confectioners and other food trades. The grains may become infested with maggots if stored under warm conditions. These insects are similar in colour to the rice. Weevils are rarely found in polished rice, this being one of the reasons advanced for this form of treatment. Weevils are, however, sometimes present in the Rangoon variety. There does not appear to be any conclusive evidence to support the need for polishing, while many objections can be raised against the desirability of the process.

Rye

While the largest crops of cereal grains are normally produced on the American continent, the greatest quantity of rye is grown on the plains of northern Europe, where it is used in the production of dark rye bread. This is more dense and moister than that made from wheat flour and takes the place of the normal wheat loaf in many countries. When mixed with wheat flour, the dough is dead and unresponsive while the colour is darker. Rye does not contain glutenin but gliadin, and the dough works up dead. It is, however, highly nutritious. The grain is extremely useful where land is poor, as it will flourish under conditions in which wheat would not survive. In the North American continent, rye is used in large quantities in the manufacture of distilled liquors, particularly rye whisky. During growth the grain is often attacked by a parasitic disease known as *ergot*, produced by *Claviceps purpurea*. When attacked by ergot, often found in Continental rye but seldom in grain produced in this country, the grain is increased in size and becomes black. This disease of the grain causes *ergotism* in human beings, the symptoms of which are diarrhœa, vomiting and, in extreme cases, paralysis. A serious outbreak of ergotism due to bread occurred in France during 1951. Rye is also affected by *smut*, which attacks most other food grains. In this country rye is eaten mainly in the form of biscuits sold under various proprietary names. Rye bread, as it is termed, must contain at least 25 per cent. of rye flour or rye meal.

Breakfast Foods

Large quantities of cereal grains are annually used in the preparation of innumerable varieties of breakfast foods, these foods having increased in popularity to an amazing extent during the last two decades. The original food of this type was oatmeal, a basic constituent of the Scottish breakfast. This material has now been superseded to a large extent by types of breakfast foods more palatable to the average consumer. Almost all the cereal grains are now subjected to a variety of processes which produce appetising and nutritious foods. Some are mixed with salt, sugar, malt, honey or bran and pre-cooked, being sold in a " ready-to-serve " condition. The greater proportion are now packed in small attractive containers for easy transport.

Various methods of cooking are used. In many cases, further heating before consumption is unnecessary. A few types require cooking, usually in boiling water, before they are eaten. The pre-treatment to which they have been subjected may hydrolyse the starch content of the grain into dextrins, but the main advantage of pre-cooking is the saving of time effected. Although nutritious, the nutritive value and weight of food material available is rarely in keeping with the increased cost of breakfast foods. The original oatmeal, while not so generally palatable as the modern processed breakfast foods, offers a much higher food value for less expenditure.

Breakfast foods manufactured from *wheat* generally retain the germ and bran. *Shredded wheat* is produced from wheat cooked under steam pressure. After cooking, the wheat is shredded by grooved rollers and pressed into the form of biscuits, which are then slightly toasted to drive off any moisture present and to darken the particles. In some instances the wheat is freed from the bran. *Puffed wheat* is softened under high pressure, which is suddenly released to explode or expand the cells, which are thus rendered porous and improved as regards digestibility. Other grains, such as rice, are treated in a similar manner. With *oat foods* part of the hull is removed. The kernels are slightly softened by means of steam, after which they are crushed or rolled. The flakes of the quick-cooling varieties are thinner and smaller, while they may be puffed for the same purpose. They are flaked by softening under steam pressure and passed between revolving rolls. *Cornflakes* are made from maize, the grain being softened by steam and the germ and hull removed. The resultant material is mixed with flavouring substances, malt extract, salt or sugar being used for this purpose, after which the maize is cooked in rotary cookers under steam pressure. The mass is then dried, flaked between rollers, toasted, cooled and packed. *Rice foods* are produced from milled rice to which various flavouring materials have been added. The rice is cooked in rotary pressure cookers, afterwards being dried, flaked, toasted, cooled and packed. Barley is also made into a number of breakfast foods. The products may be enriched or fortified with vitamin D by irradiation or, in the case of wheat products, a certain amount of irradiated yeast may be incorporated.

Composition

Cereal grains, as harvested, are usually low in fat, moisture and protein, possess a reasonably satisfactory mineral content and contain a high percentage of carbohydrate. As milling is required to improve appearance, keeping qualities and palatability, the percentage composition of the different grains may be radically altered, the starch content being increased and the fibre, mineral and vitamin content reduced. The outer part of the grain, which consists mainly of the hull and bran, are removed during the milling process to provide a more attractive and more lightly-coloured product. The *wheat* germ contains fat, minerals and protein in reasonably high percentages. The fat becomes rancid quickly, so that it must be removed if the flour is to keep well. Removal of the oil also denudes the resultant flour of some of the colouring matter. With *oats* and *rye* the greater part of the germ and a large proportion of the outer layers remain in the finished article. It is reported that the fat content is protected from decomposition owing to certain constituents in the oat kernel which prevent oxidation. The oil in the wheat germ contains substantial quantities of vitamins B and E and also some vitamin A ; in the oil from oats the vitamin A content is less. *Maize* contains a large quantity of vitamin A, not only in the oil but also in the substance. In *rice*, as already mentioned, vitamin B is located almost entirely in the bran, although a small quantity is also present in the germ. Polishing denudes the grain of much of this valuable nutrient constituent, which is indispensable to persons whose normal diet is rice. Generally speaking, oatmeal contains most fat or oil, while the lowest percentage of this substance will be found in rice. Oatmeal contains least moisture and the highest protein content ; rice flour is particularly low as regards protein percentage. The carbohydrate content in all grains is approximately the same, while the mineral content is highest in oatmeal and lowest in rice.

Wheat flour is the most important material used for the production of human food from cereal grains. After milling, chemical changes occur during storage. Some of these depend upon the conditions under which flour is stored. Flour is highly hygroscopic and can absorb large quantities of moisture, with a consequent increase in micro-organic growth and subsequent spoilage. Acidity is also increased during storage, being usually most rapid in flours which are highly refined or which show a high moisture content. Warm storage temperatures should also be avoided. Certain chemical changes during storage, due to enzymic action, are required to improve the baking qualities of the flour, which will finally exhibit an increased ability to absorb water, provide better texture and strength while giving a more satisfactory volume to the finished article. The chemical composition of wheat flour, particularly its protein content, is most important from the baking aspect. Patent flours usually have a lower protein content, although the protein is normally of very high quality. The protein of wheat flour consists chiefly of gluten, which gives the resultant dough its tough, elastic character. Gluten is a chemical compound composed of glutenin and gliadin and is not entirely a nitrogenous substance. Glutenin imparts cohesiveness and toughness to the dough ; gliadin imparts its sticky properties. These proteins are mixed with small amounts of starch, fat and ash. Starch is the principal carbohydrate and comprises three-quarters of the flour. Small amounts of sucrose, invert sugar and dextrin may also be present. Wheat flour contains little fat, for, as already mentioned, this substance is removed since it lowers the keeping quality and influences colour. The enzymes present include amylase, maltase, peroxidase, protease and tyrosinase.

Nutritive Value

Cereal products such as bread are universally acclaimed as important articles of the daily diet, irrespective of type, although in many quarters it is held that whole-meal or brown breads are most nutritious. These latter types possess a higher mineral, protein, vitamin and roughage content than is found in white bread. On the other hand, the differences in composition between the two types of bread are not extensive, and many people cannot digest the whole-meal type of bread so readily as they do the white variety. In spite of its critics, white bread is a valuable food, furnishing a readily digestible source of carbohydrate from its starchy matter, proteins and small quantities of minerals and vitamins. Cereal proteins are not fully adequate for nutritive purposes as they do not contain sufficient amounts of the essential amino-acids, although the protein content of whole wheat, oats and maize is slightly more efficient than the same quantity obtained from milk and eggs. Combined with milk, however, the result is a well-balanced meal, as the cereal proteins are adequately supplemented when milk is present. The chief nutritive constituent of cereals is the carbohydrate present in the form of starch, which is considered by nutritionists to be superior to sugar as regards its nutritional value, as it is more easily digested. This assists assimilation and utilisation. The mineral salts present in the whole grain are calcium, copper, iron, manganese and phosphorus, these minerals being present in substantial percentages although most are lost during the milling process, especially when white flour is produced. The iron present is useful in the formation of hæmoglobulin. The actual mineral content may vary considerably, being governed by the soil on which the cereal is grown and the moisture available during the growing period. Milk enhances the general food value of all cereal products either in the form of bread and milk, milk bread or with cereals of the breakfast-food variety, the protein, mineral and vitamin intake being thereby increased. Vitamin B is most plentiful, other vitamins being present in varying quantities. As before, milk enhances the vitamin content. Cereal grains provide roughage, which is of considerable assistance in combating constipation : especially is this the case if they contain much fibre, which cannot be readily assimilated. These materials contribute bulk to the intestinal contents and stimulate the normal action of the intestines in eliminating their content of digested food. This action may be increased by selecting cereal foods in which the fibre or bran remains to some extent, not having been wholly removed by excessive refinement. Excessive bran particles, however, may irritate sensitive intestines and may indeed become a cause of constipation. Breakfast foods possess an abundance of starch and a proportion of protein of lower value than the normal animal protein. If they contain the germ of the cereal and some bran, they possess a good iron content and a certain quantity of vitamin B. Bread and cereals provide approximately one-sixth of our daily diet, their consumption yielding approximately 40 per cent. of the energy and 25 per cent. of the protein obtained from the average individual's food, a quarter of the phosphorus and iron and, in the whole grains, an appreciable amount of vitamin B.

Other Starchy Foods

Arrowroot is a prepared starch obtained from the roots of *Maranta arundinacea*, grown in the West Indies. The roots of the young plants are reduced to a pulp, which is strained and washed repeatedly, the milky solution obtained being left to settle. The water is drained off and the starchy sediment dried to form arrowroot. This is a fine powder used in the manufacture of cakes and puddings which may also form part of the sick-room dietary. If stored under damp conditions arrowroot readily acquires a musty odour and taste. Great care in preparation, packaging and storage is required as arrowroot is liable to contamination from highly-flavoured or strong-smelling substances. Arrowroot has occasionally been found to be adulterated with ground rice. Mixtures of potato and maize starches have also been sold under the name of arrowroot.

Sago is obtained from the pith of the sago palm. The tree is cut into sections. The pith is scooped out, bruised and thoroughly washed. The resultant moist meal is sieved and made into pellets known as " pearl sago." The pellets are thoroughly dried on hot plates. The product is brownish or buff in colour. This farinaceous food is imported into Great Britain in large quantities and is used in the production of nutritious puddings when cooked in milk. *Pearl tapioca* has been moulded to form imitation sago and has been sold as such, often at a higher price. This article is white in colour and does not possess the slightly earthy taste which is characteristic of sago.

Tapioca is obtained from the root of the cassava or manioc plant, which is indigenous to Brazil and East and West Indies. The roots are reduced to a pulp and the juice, which in some species contains hydrocyanic acid, is washed off, the starch being allowed to settle. This material is first sun dried. It is then heated or roasted on metal plates, after which it is again dried, being frequently stirred during the process. Large and small grains are formed by the heat treatment, which removes any traces of hydrocyanic acid which may have been present in the unheated starch. The final product is graded by sifting and is used in the preparation of soups and milk puddings.

Epidemiology

Many bakery products have been involved in outbreaks of food poisoning and other diseases, particular in the case of cream-filled articles. It should always be remembered that starchy matters, sugar, milk and eggs, which are all used in the production of such articles, form a suitable medium for bacterial development. Cream pastries have been implicated in many *food poisoning* outbreaks both in this country and abroad, the main causative organisms being *Salmonella typhi-murium*, *Salmonella enteritidis* and *Staphylococcus aureus*. In the Farnworth district of Lancashire in 1949, fifty-six cases of food poisoning were notified with one death. Vanilla slices were apparently the cause of the outbreak and it is believed that the causative organism, *S. typhi-murium*, originated in ducks' eggs used in the composition of the filling. *Typhoid* and *paratyphoid fevers* have been caused by a variety of bakery products, infection occurring either directly from affected persons or from " carriers " handling the materials during or after production. An outbreak of paratyphoid fever occurred in 1941 which was traced to a girl in a bakery who filled cream cakes from paper bags, the corners of which she bit off with her teeth before squeezing out the cream. In the Liverpool area, 123 cases of paratyphoid fever occurred following infection induced by the consumption of infected jam sandwiches at a bakery where a " carrier " was employed. Kitchen hands who have sliced bread for subsequent use have been implicated in several such outbreaks, as they have in outbreaks of *Flexner and Sonne dysentery*. In almost every case it has been found that baking temperatures were insufficient, or that unhygienic methods of handling and dirty conditions generally were responsible. Unwrapped bread has been found to have a high bacterial content upon the external surfaces ; in many cases intestinal types have been isolated. As with all types of food, hygienic care in handling during production, sale and distribution is of the utmost importance. In connection with confectionery, an interesting outbreak was reported from Lambeth in 1948. This was caused by the consumption of cream buns, the piping bag used to fill the buns having been infected with *S. œrtrycke*, probably by a human " carrier " whose stools were shown to contain the organisms. This illustrates the need for scrupulous care during all stages of manufacture and handling, and also points to the wide net which must be cast by any investigation.

Control

Bakery premises must be kept in a highly satisfactory and sanitary condition if the resultant products are to be clean, uncontaminated and uninfected, constant supervision being necessary for this purpose. The conditions at present existing in many small bakehouses are most unsatisfactory indeed, improvement being urgently required. Bakehouses should not communicate with living or sleeping rooms ; walls and ceilings should be constructed of impervious materials which are capable of being readily cleansed, while all floors should be impervious and well drained. Light and ventilation must be adequate. All door and window openings should preferably be screened to prevent the entrance of flies and other insects. A pure water supply is essential, together with adequate toilet facilities sufficient for the number of employees, soap and towels and proper sanitary accommodation. Machinery should be readily accessible for cleansing purposes and its design should be such as will facilitate this operation. In shops the shelves and showcases should be kept in a clean condition, uncontaminated by flies or other vermin. Many bakehouses and shop premises are infested with rats and mice together with flies, cockroaches, ants and other insect pests. It is important that systematic measures of destruction should operate continuously. Fumigation of the premises should be frequently carried out. The advantages of D.D.T. and Gammexane, properly used, may also be mentioned. Both bakehouse and shop equipment should be cleansed daily, being well scrubbed, using an adequate quantity of hot water. All dirt, dust and cobwebs must be removed from *all* parts of the premises. The floors should be scrubbed daily and the windows maintained in a clean condition. Particular care is necessary in connection with piping bags as it appears unlikely that metal syringes will ever replace the fabric bags more generally used. These bags are made from various materials, all of which are difficult to clean, in addition to which they allow cream or icing to exude on to the hands of the worker. They are extremely difficult to cleanse and the rubber-lined variety are to be preferred, even though frequent boiling will cause the rubber lining to deteriorate. Customers in confectioners' shops should not be allowed to handle or touch any of the articles exposed for sale. Delivery vehicles should be kept in a thoroughly clean condition. The refuse from all premises should be suitably stored and removed daily so that no harbourage for vermin is provided. The personnel require careful supervision. All employees should be medically examined when they commence employment and at subsequent periodic intervals. Spitting or smoking while at work should be prohibited. The employees should not be allowed to sit or lie on work benches during their rest periods. They should be free from any obvious type of infection or skin disease and should be required to wash their hands and arms frequently and to keep their finger-nails clean. The finger-nails and hands should be inspected daily for cleanliness and for freedom from skin disease or abscesses or eruptions. Employees with coughs and colds should not be allowed to handle food products. An employee who has been in contact with a case of infectious disease should either be laid off work or temporarily transferred to work which does not expose food to infection until the period of quarantine is at an end. The action taken will depend on the degree of contact and the infectious disease concerned. Prominent notices should be displayed reminding employees to wash their hands after using the W.C. In general, as with all food-producing premises, absolute and unvarying cleanliness is essential in bakeries and distributive premises.

The *chemical examination* of cereals, flour and bakery products is mainly directed to estimating moisture, ash, gluten and fibre contents ; the acidities of the various substances may also be determined. The addition of alum, salt content, use of improvers, mineral additions and the use of bleaching agents is also investigated, as is the possible fortification of flour by the addition of calcium carbonate. The examination of self-raising flour may be carried out, while both the grain and flour are examined for the presence of insect pests and other parasitic conditions. The presence of foreign starches, silica, alum or copper sulphate in bread may require investigation. The *bacteriological examination* of flour and bakery products is sometimes undertaken as regards bacterial content, particularly food-poisoning organisms, coliform contamination and the presence of other organisms and spores, particularly those which are the cause of ropiness.

CHAPTER XXII

FRUITS

THE consumption of fruit, particularly of fresh fruit, has increased enormously during the past ten to twenty years, mainly due to a realisation by the public of its value from the nutritional point of view. Present periodical shortages, particularly in the case of imported fruits, have prevented a full realisation of the consumers' desires in this respect, but normal conditions will no doubt see a rapid expansion in the fruit trade to still greater heights. Apart from its nutritional value, the demand for fruit has stimulated improved methods of transport which, in turn, have enabled deliveries to be rapidly made, so that fruit very often reaches the table soon after it has been gathered, and in an appetising and fresh condition. Improved methods of packing and grading, particularly in the case of foreign fruits, have done much to increase sales, while the demand for what were once considered luxury fruits, such as peaches, apricots and grapes, is continually increasing. Large quantities of fruit pulp are also imported from abroad and may contain, as a preservative, sulphur dioxide in the ratio of 1,500 parts per million. The exceptions, which will be considered later, are cherry, strawberry and raspberry pulps, which must not contain any preservatives.

There are two main types of fruit, the *hard variety*, which includes apples and pears, and the *soft fruits*, of which raspberries and strawberries are typical examples. Soft fruits quickly decay, particularly if over-ripe, bruised or damaged in any way. This type of fruit putrifies quickly under warm, damp conditions. Over-ripe or decayed fruit, if consumed in excess, may cause diarrhœa or other intestinal disorders. Different fruits possess different characteristics. Some contain more sugar than others and different types of acid, whilst most fruits possess a carbohydrate content in varying proportions known as pectin. Many fruits are packed before they are quite ripe, as in this condition they can be easily transported and are better enabled to reach their final destination in prime condition. Fruit should not be bruised by rough handling during packing or transportation, otherwise decomposition is likely to be rapid. Soft fruit is easily damaged and is often offered for sale in a partly decomposed or fermented condition, especially on markets, street-barrows and in small shops. Decayed fruit may be readily recognised by its soft appearance, by changes in colour and by external moulds.

Apples

Of all the various types of fruit available for human consumption apples are the most popular and widely-used variety. They have been appreciated as a food for many centuries. Apart from the extensive crops grown in this country, large quantities of apples are imported annually from abroad. It is to be regretted that in this country, where apples are grown to perfection, little interest appears to be shown in methods of grading, packing and marketing. Far too often small maggoty apples are sold in this country at ridiculous prices. It is not too much to hope, perhaps, that competition from abroad will spur British growers to improve their present all-too-often unsatisfactory methods of handling, packaging and distribution.

Many varieties of apples exist. Each type has different uses and differs widely in characteristics. Some are excellent dessert apples but possess a good flavour for a brief period only, after which they quickly decay and become unfit for human consumption. Others have excellent keeping qualities ; indeed, with this type storage is required so that full flavour may develop before they are eaten. This latter type is usually capable of transport and storage without serious loss of condition. Other varieties are suitable for cooking only, lacking the fine flavour and sweetness of table apples. Quite a large percentage possess no particular characteristics but can be used for various food purposes ; some can either be eaten raw or cooked, thus serving a dual purpose. Dessert apples should be sweet and juicy and should possess an aromatic flavour. The cooking variety should form a soft, pulpy mass when stewed or baked. Apples are not highly digestible when eaten raw ; when cooked they form a useful food which exerts a gentle laxative influence. Apples have a moisture content of approximately 84·1 per cent., and a high percentage of carbohydrate (9 to 21 per cent.). Their protein content is approximately 0·3 per cent., their fat content 0·5 per cent. The mineral matter averages 0·4 per cent. Vitamins A, B_1, C and G are present, the vitamin A content being greatest.

During growth, apples may be attacked by various *bacterial, fungoid or insecticidal pests* which can seriously affect the final quality. Among these are scale, codling moths, blights, scab, fungus rots and caterpillars. Sprays and dusts are used for control and prevention. Certain *arsenical compounds*, such as lead arsenate and lead hydrogen arsenate, have been found useful for this purpose. These compounds may be dangerous to the consumer if present on the fruit in excessive quantities. Their increasing use has been viewed with alarm in many quarters, as the skins of the apples so treated have been found coated with excessive quantities of arsenic on a number of occasions. Indeed, many authorities are of opinion that imperfect fruit is preferable to that which has been contaminated in this way, as, if consumed in sufficient quantities, arsenical poisoning and even death may result, especially when the fruit is eaten in a raw unpeeled condition as is so often the case with dessert apples, particularly in the case of children. Various methods for the removal of such compounds have been employed. While there are no Regulations in this country dealing with the employment of such spraying materials, much attention has been given to this matter in foreign countries, particularly in the United States of America. Legal standards relating to the quantity of arsenic which may be present have been formulated. Brushing or wiping will not entirely remove these poisonous compounds, but weak solutions of hydrochloric acid have been found satisfactory for removing such contamination. The fruit is washed in running water following treatment with the acid, to prevent injury.

Apples are affected with a number of *diseases* which appear during the time they are stored, although infection may have occurred during growth or transport. A condition known as *brown heart* occurs mainly in apples from Australia or New Zealand and is difficult to detect by external inspection. When the affected apple is cut, a brown discoloration is found. This spreads from the core outwards, the whole fruit eventually becoming soft. This defect is due to the presence of abnormal quantities of carbonic acid gas and is aided by storage in badly-ventilated ships' holds. Another condition known as *scald* occurs, mainly in apples from North America. A small brown patch discolours a portion of the skin. This eventually spreads into the substance, rendering it uneatable. Wrapping in waxed paper partly assists in mitigating losses through this disease. Apples affected with *ripe rot* show brown sunken spots, the fruit becoming dry and the skins wrinkled and yellowish. White growths are sometimes found on the external surfaces. *Apple scab*, denoted by black scabby marks on the skin, does not damage the fruit. *Glassiness* is often found, the fruit being watery fleshed. Shallow pitting of the surface denotes a condition known as *bitter pit*. Under the pit marks are areas of dead brown flesh. Grubs of the *codling moth* sometimes eat their way into the pulp and seriously damage the fruit. Most of these conditions may be avoided by proper selection and handling during growth and storage.

As apples are continually in demand, proper storage is important. The premises used for this purpose should be well ventilated and reasonably humid, while temperatures should be maintained in the region of 36° F. Only sound fruit should be stored, as the fungi which cause the fruit to rot develop at low temperatures. Any infected or rotten fruit will affect any sound fruit which may come into contact with it. Bruised fruit should be removed as soon as discovered, since bruises become foci of infection and deterioration. Any apples with breaks in their skins or with stalks pulled out should also be discarded. Apart from the diseased conditions already mentioned, which may spread to sound fruit during storage and which can be minimised by careful gathering, washing and packing with refrigerated conditions of storage, the apples themselves may produce gaseous metabolic products which will accumulate and affect the fruit. For this reason adequate ventilation must be maintained in all storage rooms. Wrapping of the fruit before it is packed will also do much to minimise this condition, particularly if oiled paper is used. The oil used for impregnation will absorb these gases. Internal browning or breakdown may occur if the apples are stored at temperatures too near freezing point. In some instances the apples may be affected with a blue mould. They must then be washed in a dilute solution of sodium hypochlorite before sale. These sterilising solutions are extremely useful in the treatment of containers used during picking and for storage boxes, which may seriously contaminate the fruit. Carbon dioxide has been found very valuable for lowering the incidence of deterioration and fungus spoilage. Gas storage on these lines is becoming popular. This method is also employed on ships engaged in the transportation of apples. It should be noted, however, that all varieties of apples do not lend themselves to this treatment. The proportions of carbon dioxide and the temperatures which suit one variety may be deleterious to another.

Apart from being eaten as fresh fruit, the *uses* to which apples are put are numerous. They are used for cooking, in pies, as sauces, in chutney manufacture, for jellies, jams and marmalade and for cider making. Pectin, used in the manufacture of jams and jellies, is largely obtained from apples. In addition, great quantities of low-grade apples are canned for bakery and restaurant use. The flesh should be white and firm ; normally the cooking varieties with high acidity content are used for this purpose. Apples for canning are washed, peeled, cored, trimmed, cut into portions and treated with dilute brine to prevent oxidation and subsequent darkening. They are then blanched to drive off the oxygen and destroy the oxidate present. Steam boiling, brine, brine under vacuum or prolonged heating in hot water are the methods used for this purpose. The cans are filled and exhausted, the latter process being important in order to reduce any likely action due to the presence of malic acid and oxygen, which may cause corrosion or pin-holing of the cans. Sterilisation is carried out, followed by rapid cooling. The sterilisation temperature is usually in the region of 212° F. and is applied for ten minutes. During this time the cans should be agitated, the natural acidity of the fruit assisting in the destruction of any bacteria present. Apples contained in cans, other than solid pack apples and apple puree, should be packed in light syrup between 14° and 17·5° Brix. Apples for bakery use are also frozen, in cans or other containers, being sometimes packed in syrup. Dilute sulphurous acid is used to prevent darkening of the tissues. Apples are also packaged and subjected to the quick-freezing process, while large quantities are dehydrated for future use.

Apricots

Large quantities of apricots, a fruit akin to the peach, are imported annually from abroad. Enormous quantities are canned, usually in syrup, in those countries in which the apricot is grown. If packed in an A10 can, a light syrup between 14° and 17·5° Brix should be used and the container labelled accordingly. With this size of can, the fruit may also be packed in water, provided a clear indication is given on the label. In other sizes of cans the syrup should be 39° Brix. The apricot is a stone fruit which is occasionally eaten raw but generally cooked or made into some form of preserve. The kernels of some varieties are edible. The liqueur, eau de noyeaux is prepared from bitter apricot kernels. The fruit is easily damaged. Decay often occurs near the kernel, due to depredations of the larvæ of the common fruit fly. Apricots contain no fat, have a reasonable quantity of carbohydrate in their composition (12·0 per cent.), little protein (1·1 per cent.) and a good mineral content in addition to moisture. They possess a high vitamin A content, whilst vitamins B_1, C and G are also present. They form a nutritious food.

Bananas

The nutritive value of bananas has been appreciated for many centuries. The main sources of supply are the West Indies and countries in the Caribbean area, together with the Canary Islands, Africa and parts of Asia. The growing, transport and sale of bananas has resulted in the development of large organisations to cope with the public's requirements. Twelve to fifteen months must elapse from the time the pieces of root, each of which ultimately forms a banana tree, are planted until the fruit is ready for cutting.

When the bunches, or "stems," are cut, they must be provided with speedy means of *transportation* to enable them to reach the consumer in perfect condition. Not only must suitable methods of transport to the coast be available ; special ships are employed for this purpose. From the port of arrival special vehicles are used to effect delivery to the various towns. The main transport essentials to ensure delivery to the consumer in prime condition are speed and care in handling together with the use of refrigeration or heat where necessary. The fruit must not be bruised during cutting and subsequent transport. Bananas are green when cut. Special conveyors are used to prevent damage when the boats are loaded. The temperature of storage in the ships' holds is maintained at approximately

57° F. by means of efficient ventilation together with heat or refrigeration, as may be necessary. Bananas are damaged if temperatures are allowed to fall below 50° F.; if exposed to cold winds or frost the skins become blackened. If exposed to cold atmospheres when green, the fruit never ripens and has a soft feeling when handled. During transport the fruit is held in racks to prevent bruising and injury. In hot weather, cooled fresh air which has passed over refrigerated brine coils is circulated through the storage rooms. The circulation of air is essential to remove carbon dioxide which results from the metabolism of the fruit owing to its natural respiratory processes. In order to conserve fuel, insulation is usually provided to storage rooms. To ensure the maintenance of adequate temperatures, heating systems are provided for use during cold weather. This care is exercised throughout the fruit's journey to the consumer. Specially insulated wagons are used so that suitable conditions and ventilation are assured. Final delivery takes place in boxes, the fruit being packed in straw.

If bananas are yellow in colour when they arrive from abroad they must be sold immediately, otherwise they are likely to perish rapidly and become useless for food. The *ripening* of bananas on the tree is never allowed, as the fruit would then be insipid and lack its characteristic flavour. The change in colour from green to yellow during ripening is due to the breakdown of the chlorophyll in the skin. This enables the yellow pigment produced by xanthophylls and carotene to become apparent. Temperatures between 60° F. and 62° F., together with suitable ventilation and humidity, are essential for proper ripening, which takes from four to nine days, according to the condition of the fruit when the ripening process commences.

The *food value* of the banana is appreciated in this country, but not to the same extent as in tropical areas, where this fruit represents the chief carbohydrate consumed. The chemical composition of the banana is almost similar to that of the potato, although it has a higher calorific value. The unripe fruit is rich in starch, which changes to sugar during the ripening process. The protein content averages 1·3 per cent. but the fruit contains little fat. It contains a fair amount of moisture and is a good source of mineral salts. It also contains vitamins A, B_1, C and G. It has been estimated that eighty bananas of average size would be required to supply sufficient daily energy to the body. Owing to its low protein content, twice this number would be necessary to supply daily bodily needs. Banana powder and dried bananas are now produced in order to save shipping space and to preserve what is normally a perishable food for future use. These substances have not attained any great popularity although it is stated that the vitamin content and the natural enzymes are preserved by processing.

Cherries

The cherry is a sub-acid fruit with a characteristic flavour. It is used both as a dessert fruit and for cooking purposes. Large quantities are employed in jam manufacture, for the production of cherry brandy and other liqueurs, such as kirschwasser and maraschino, by distillation of the liquor from the fermented pulp. Cherries are packed in A10 cans either in water or in a light syrup (14° to 17·5° Brix). In all other cans, the syrup must be not less than 32° Brix. Prime cherries are grown in large quantities in this country and are also imported from the Continent. The fruit can be affected by numerous pests, brown rot, fungus growths and moulds.

Imported cherry pulp intended for use in jam making is allowed to contain sulphur dioxide as a preservative in the ratio of 3,000 parts per million. Cherries contain approximately 0·8 per cent. fat, 1·0 per cent. protein and 16·5 per cent. carbohydrate.

Citrus Fruits

The principal citrus fruits used for human consumption are grape-fruit, lemons, limes and oranges. Large quantities are imported each year to supply the increasing demands of the consuming public and manufacturers. Not only are the ripe fruits consumed in their natural state in many cases but large quantities are manufactured into marmalade, while their juices are expressed for bottling or canning, to be used subsequently in their natural state or as a basis for cordials and fruit drinks. Citrus fruits contain large quantities of water, but only small amounts of fat and protein. They also possess small quantities of the characteristic volatile oils. Their carbohydrate and acid content is responsible for their flavour. They are extremely prolific sources of vitamin C. Nutritional experts have stated that the acidity of the blood is slightly reduced by the ingestion of citric acid, which they contain.

Numerous by-products are obtained from citrus fruit. *Canned grape-fruit* and *orange juice* are now widely available. Frozen juice is also obtainable. A certain proportion of juice is dried, while lemon and orange oils are manufactured for confectionery purposes. Pectin for use in jelly and jam manufacture is produced in large quantities ; citric acid is obtained from the low-grade fruit and skins. *Candied peel* which has been preserved with sugar is also an important by-product, while jellies and marmalades are produced in large quantities from the separate fruits or by a combination of fruits.

Grape-fruit. The grape-fruit has become exceedingly popular during the last few years. Large quantities are imported annually, principally from Florida, California and South Africa. The grapefruit is similar in appearance to a large orange except that it is yellow in colour. The fruit possesses an acid taste which is also slightly bitter but appetising and is an acquired taste. Vitamins B_1 and C are present. Sugar is often added to increase the sweetness during consumption, particularly as a breakfast dish. The juice and pulp are also canned in large quantities, being sweetened before canning takes place. The transport and distribution of this type of fruit is carried out in a similar manner to that of oranges. Grape-fruit are sometimes treated to produce the desired colour changes in the mature fruit. Ripening can be accelerated if the fruit is stored at a temperature of 75° F. Ethylene gas is employed in the ratio of 1 cubic foot of gas for each 20,000 cubic feet of storage space. The fruit is subject to attacks by moulds, which cause rapid deterioration. They are generally packed in boxes, being individually wrapped in tissue paper.

Lemons. Lemons are grown in many tropical and sub-tropical regions, the Mediterranean countries being particularly lavish producers of this fruit. Large quantities are imported into this country each year. The fruit is cut from the trees while still green and ripened under controlled conditions to improve the flavour and keeping qualities. Ethylene gas is often employed for this purpose, 1 cubic foot of the gas for each 20,000 cubic feet of storage space being required. The temperature of the ripening rooms should be maintained at approximately 70° F. Lemons keep better than oranges and are not so readily subject to damage. They possess high citric acid content. This property retards fungoid deterioration. Besides citric acid the fruit contains malic acid, salts, gum, fat, sugar and albuminous matters. Each fruit during transport is usually separately wrapped, and packed in wooden boxes. Large quantities of citric acid for use in the production of aerated waters are obtained annually from poor-quality lemons ; pectin is another important by-product. The juice has extremely good antiscorbutic properties and contains a large amount of vitamin C. For this reason it has been extensively used in the treatment of scurvy on shipboard, although it has now been largely superseded by lime-juice for this purpose. A little vitamin B_1 is also present. Lemons are also useful sources of many substances used in medicinal preparations. Candied peel is an important by-product, being prepared from the skins of the fruit, which has been previously pickled in brine for transport, thoroughly soaked in fresh water to remove the salt, and finally preserved with sugar. The fruit is extremely subject to attacks of blue or green moulds which are the cause of rapid deterioration.

Limes. The lime is an oval greenish-yellow or yellow-coloured fruit almost similar to a lemon in shape, but smaller. It is very acid and unsuitable for eating in its raw condition. The tart flavour of its juice makes it an important constituent of many fruit drinks. Bottled lime-juice is popular, not only for its refreshing taste but for its medicinal properties. Limes contain a good supply of vitamin C and have long been recognised as an antidote to scurvy. The fresh fruit is extremely perishable. For that reason storage under refrigerated conditions is essential if the fruit is to be kept for any length of time. The main sources of supply are the West Indies and Florida, where large quantities of juice are extracted from the fruit and concentrated for subsequent use. Lime marmalade is also manufactured.

Oranges. Apart from the apple, the orange is probably the most popular fruit obtainable in this country at the present time. Large quantities are imported annually from almost every tropical and sub-tropical country each year. There are a number of main varieties of oranges, of which perhaps the *Navel orange* is the most popular, this being a large seedless type which has a fine appearance and keeps well. The *Jaffa* is a large fruit with a thick skin, much esteemed owing to its sweetness. *Mandarines* and *clementines* are other sweet varieties which are very popular. The *Valencia* is the commonest type. It is usually sweet although much smaller than the two first mentioned varieties. The *Maltese* or *blood orange*, the pulp of which has red streaks throughout the flesh, and the *tangerine*, a small sweet orange with many seeds and an easily removable skin, are two other main dessert varieties. The marmalade industry owes its success to the *Seville* or *bitter orange*, which is too sour for eating in its natural state.

As the fruit has to travel considerable distances to reach the point of consumption, great care is necessary during *handling and transport*. Oranges are normally gathered in a green or partially-ripe condition. Their readiness for gathering is generally determined by the ratio of their total solids, mainly sugar, to the acid content. This information is obtained by examination of their expressed juice. This ratio is usually in the neighbourhood of 8 to 1. Oranges must be handled carefully during gathering so that they are not injured or their skins broken. The stems are cut as close to the fruit as possible. This is important, as oranges are subject to mould growth which will reduce them to a sodden condition. These moulds, the chief of which are *Penicillium digitatum* and *Penicillium italicum*, may also pass from fruit to fruit in direct contact to infect large numbers. Hygienic handling is essential to prevent difficulty arising from this source. Apart from care in handling, proper low-temperature storage is required. Oranges are sometimes treated with solutions of borax to check the growth of micro-organisms. Application of dilute sodium carbonate solution is made to prevent infection by moulds.

The *colour* of fruit when gathered and when ripe varies. Some varieties may be quite green even when in ripe condition ; others display the familiar yellow or orange colour, although they are still immature and change to green later. Valencias change from green to yellow when the chlorophyll is dissipated on the trees, remaining dormant in autumn but changing back to green when the tree becomes active in the spring. As green fruit is not acceptable to the consumer, artificial colouring methods are employed, ethylene gas being used for this purpose. This treatment accelerates destruction of the green chlorophyll and permits the yellow pigments which colour the skin to become apparent without any change in composition taking place. During the process the control of temperature, air circulation and concentration of the gas are important. The concentration of gas employed varies. As little as 1 part in 20,000 has been employed, the period of application varying from twenty-four to sixty hours. This gas should be used only on mature oranges. Lemons, grape-fruits, pears and tomatoes may be similarly treated. Special colouring rooms are used for the storage of oranges during treatment. Temperatures between 70° F. and 80° F. or above are employed, while the humidity should be relatively high, being between 85 and 95 per cent., to prevent loss of moisture in the fruit due to evaporation. This treatment causes the fruit to give off increased quantities of carbon dioxide gas during its normal respirations. If the percentage of this gas in the air of the colouring room rises excessively the action of the ethylene gas will be retarded, while the fruit may be injured. Efficient ventilation of such rooms is therefore essential. Four cubic feet of the gas is usually employed for each 20,000 cubic feet of air space. Acetylene gas has also been used, but acts less rapidly. The treatment of fruit with gas is reported to impair slightly its keeping qualities. Experiments in colouring fruits with dyes have been made in America, but the employment of such substances should always be viewed with suspicion.

Because of the temperature of the storage rooms, the treatment of oranges in this manner may cause mould or rot to develop. For this reason the oranges are usually washed after treatment in a 6 to 8 per cent. borax solution at temperatures between 110° F. and 117° F. for a brief period. If the fruit is slightly warmed, crystallisation of the borax is prevented. This rise in temperature assists in the development of colour, particularly during cold weather. Some fruit does not require any special treatment to improve or develop the required colour, but it is often treated with borax to prolong its storage life. Various detergents are sometimes used to wash dirt, insects and other foreign materials from the fruit, but this treatment must be followed by washing in clean water. The skins are occasionally polished by means of resin, paraffin or mineral oils, these substances being applied by means of a fine spray while the fruit is brushed mechanically to give the skins a fine glossy finish. This treatment, besides improving the appearance, leaves the fruit with a surface almost impermeable to moisture, retards moisture losses from the pulp and prolongs the keeping qualities.

Oranges are finally graded according to size, individually wrapped in tissue paper which is sometimes oil-impregnated and finally packed in cases or crates. Keeping quality is prolonged by means of low-temperature storage, temperatures of between 40° F. and 45° F. being employed. Lower temperatures are not advisable as, if used for long periods, they cause changes to take place in the fruit.

The orange forms an agreeable and wholesome article of diet and contains a large percentage of citric acid and vitamin C. In addition, it possesses anti-scorbutic properties of considerable value. Vitamins A, B_1 and G are also present, while fat, protein and carbohydrate are found. Its value to the health of the consumer, particularly during the winter months, is considerable. Large quantities of orange juice are used annually in the form of fruit drinks ; a certain quantity is also concentrated for future use. The skins are treated with sugar or " candied " for use by confectioners, while orange essence is also extracted from the skin, to be employed as a flavouring material. The bitter or Seville oranges are employed for the production of orange marmalade or are used in conjunction with other citrus fruits for the same purpose.

Currants

Black, red and white currants have been grown in this country for many years and are much valued for culinary and medicinal purposes. The fruit is very easily damaged and extremely perishable. The main uses of this fruit are for the production of jams and jellies, although large quantities are also sold for confectionery fillings in the form of fruit pies and tarts. The syrup of the black-currant is concentrated and bottled for consumption by children, being particularly valuable as a source of vitamins, particularly vitamin C. Currants contain no fat, a little protein and the carbohydrate content averages 12·8 per cent. The juice is also used in the production of pharmaceutical preparations, particularly as an ingredient of throat lozenges. Black- and red-currant juices are also employed as flavouring and colouring agents for cordials.

Gooseberries

The gooseberry, which is closely allied to the currant family, is a popular fruit, used mainly in the production of jams and jellies and also for culinary purposes. Red, yellow, white and green varieties are grown, the first two types, sometimes known as dessert gooseberries, being easily damaged. During growth the fruit is often affected with what is known as " gooseberry mildew." This is indicated by glistening white spots which appear on the fruit. When ripe, fermentation of the juice with sugar results in the production of an excellent wine. Ripe gooseberries contain a large percentage of sugar, particularly the red and yellow varieties, the amount varying from 8 to 12 per cent. A little protein is also available. Acidity is due to the malic acid content. A fair amount of vitamin C is present.

Grapes

Formerly looked upon as a luxury fruit, improved methods of transport have enabled large quantities of grapes to be imported from abroad, so that the sale of hothouse or home-produced grapes has been largely superseded by those grown in the open air in sub-tropical countries. Apart from their value as an addition to our fresh fruit supply, large quantities of grapes are dried to form raisins, sultanas or currants. They are also the basic product for the manufacture of wines of all types, large quantities being grown specially for this purpose. The numerous varieties are each grown with a different end in view. Some are most satisfactory for table use, others are used almost entirely for wine making, whilst some varieties, such as the seedless types, are almost invariably dried. The growing vines may be attacked by mildew, which causes the fruit to shrivel. Rain during the period when the fruit is reaching maturity favours attacks by mildew and fungi, which find grapes exceedingly suitable for development. The handling of grapes during harvesting and their transport is important. Great care is necessary, as the fruit is easily damaged and quickly ferments. Table grapes naturally receive the greatest care. It is usual to wrap each bunch separately in wax or tissue paper, or in cotton-wool, before packing the fruit in wooden crates or boxes. The cheaper grades are usually packed in barrels or boxes, surrounded by sawdust or cork dust. Large quantities of imported grapes are treated in this way. All types of grapes should be kept cool and dry. When grapes are required for drying into raisins, etc., they receive less care. When required for manufacture into wine, they are often roughly handled. Storage temperatures should never fall below 30° F. A humidity in the store atmosphere of between 80 and 90 per cent. is necessary to prevent moisture losses in the fruit. Apart from their use as fresh fruit and for manufacture into wine and dried fruits, large quantities of grape juice are canned, benzoic acid being allowed in the ratio of 2,000 parts per million. The fruit is also used for the production of jams and jellies. Tartaric acid and tartrates are obtained from grapes, being by-products of the wine industry ; vinegar is also obtained by means of aerobic bacterial fermentation of wine. Grapes, which contain a high percentage of sugar and some malic acid, together with a little fat and protein, have a high nutritive value. The vitamin C content is high, whilst vitamins A, B_1 and G are also present.

Medlars

The medlar, which is similar in shape to a pear, is not a popular article of diet. It is not fit to eat until it begins to decay and become " bletted." In this condition it is quite fit for consumption and has an agreeable acid and somewhat astringent flavour. There are several varieties of medlars, including one which is stoneless. The quality of the latter type is not very high. The fruit is usually gathered in the late autumn, preferably during dry weather, and is laid on shelves. It requires two to three weeks' storage to become " bletted " and fit for use.

Peaches

The importation of increasing quantities of peaches has considerably reduced the price and has placed the peach within the reach of almost everyone. In some countries, particularly in America, the growing of peaches has developed into a major industry. The fruit is extremely perishable. During growth it is often affected by the larvæ of the common fruit fly, which causes decay near the stone. The finest varieties are most difficult to transport owing to the ease with which they are damaged and deteriorate. There are two classes of peaches, clingstones and freestones, the sole difference being the ease with which the pulp can be separated from the hard stone. The colour varies from white to deep yellow with red patches. The fruit is widely eaten in a fresh condition. Large quantities are canned either in a light syrup (14° to 17·5° Brix), water, or in a heavy syrup (39° Brix). They may also be dehydrated for future use. The fresh fruits are usually wrapped in tissue paper and packed in shallow boxes. Low temperatures are required for storage and during transit, but the fruit does not lend itself to transport over long distances. The skin is downy, being covered with innumerable fine hairs. The flavour is extremely delicate, the pulp containing a high proportion of juice when the fruit is ripe. Peaches contain a little fat and protein, whilst their carbohydrate content averages 9 per cent. The *nectarine* is a variety of peach. It is sweeter, while the skin shines and is free from down or hairs.

Pears

Pears grow well in all the temperate zones. Large quantities are produced and consumed annually, although, in spite of their flavour and increased juiciness, they have never attained the popularity of apples. This is probably due to susceptibility of pears to disease and to the difficulties experienced in storage and transport, particularly in the case of the soft varieties, which are easily bruised and damaged and subject to rapid decay. The hard types, used mainly for cooking, will withstand transport much more successfully. Like the apple, the pear may suffer from a number of fungoid and bacterial diseases, such as blight, scab, glassiness and bitter pit. If the fruit is allowed to remain on the tree until ripe, it is lacking in flavour and becomes coarse in texture. For this reason pears are harvested when they have reached full size but have not started to soften. To obtain the fine grain and juicy flavour appreciated by the consumer, pears are usually ripened in trays at temperatures in the region of 70° F. Cold storage at temperatures just below freezing point is required if the fruit is to be stored for any length of time. Too lengthy periods of storage, however, will be followed by rapid deterioration. If pears are to retain a marketable condition, the optimum storage period is approximately two months. Gas storage has been successfully applied, as in the case of apples. If pears have to be transported any distance they must be maintained at temperatures of 40° F. to 42° F. during transit. Pears are also canned either in water, in a light syrup (14° to 17·5° Brix) or in a heavy syrup (39° Brix).

Pears rapidly discolour after the skin has been removed unless their oxidase system is destroyed. Large quantities of dried pears are imported annually, being either naturally dried in the sun or artificially dehydrated. Still larger quantities are canned in syrup abroad. In this country *perry* is produced from pears by a similar method of manufacture to that required for cider. The pear contains a fair proportion of sugar, a small quantity of citric acid, a little fat and protein together with vitamins A, B_1, C and G. *Quinces*, which closely resemble pears, are not grown to any great extent in this country and are mainly used in the domestic manufacture of jam, forming an excellent preserve. The fruit has a powerful odour and is rarely eaten in its raw state since it possesses an astringent flavour.

Pineapples

Although a small quantity of this fruit is imported from tropical countries for consumption in its raw state, the bulk of the fruit grown is canned in syrup and imported in that form. In addition, large quantities of crushed or pulped pineapple, either sweetened or unsweetened, together with canned pineapple juice, are also imported. The pineapples or pulp may be packed either in water, in a light syrup (14° to 17·5° Brix), or in a heavy syrup (39° Brix). In its raw state it will stand rough handling and exhibits lengthy keeping qualities. Pineapples are affected with black-heart disease, which causes the centre of the fruit to turn black. Putrefaction is evidenced by the appearance of brown patches. This causes the fruit to become soft and pulpy. Pineapples possess a carbohydrate content in the region of 12 per cent. together with a little fat or protein. Vitamins A, B_1, C and G are also present.

Plums

This fruit is extremely popular both in the raw and cooked condition, and it grows well in all temperate regions. Numerous types of cooking and dessert plums are available, among them Victorias, egg plums, damsons and greengages. The colour of the fruit when ripe varies from yellow or green to deep purple, while sizes of the different varieties also vary considerably. Similarly, the flavour and season of ripening are subject to considerable variation. Plums of all types are attacked by a number of grub and fungoid diseases, of which silver leaf is the chief. This fungus causes the fruit to shrivel and become tasteless. Plums are occasionally sharp and sour. They form an exceedingly perishable fruit, although modern methods of cold storage enable them to be transported over long distances. One of the main causes of decay is brown rot, which affects all varieties. Large quantities are canned for future use, being packed either in water, in a light syrup (14° to 17·5° Brix), or in heavy syrup (39° Brix). Plums contain no fat, a little protein and a carbohydrate content in the region of 17 per cent. Vitamins A, B_1, C and G are also present. Abroad the fruit is either sun dried or artificially dehydrated and the stones removed to form *prunes*, a popular form of dried fruit used for culinary purposes.

Raspberries

This popular but exceedingly perishable soft fruit is frequently eaten in its raw state, but is generally used in the manufacture of preserves. Raspberries are particularly liable to rapid deterioration when gathered in a wet condition and will quickly decompose. Their flavour is appreciated by many people in preference to that of strawberries. They contain no fat, a little protein and the carbohydrate content averages 10 per cent. Vitamins B_1 and G are also present. Raspberries are often canned or subjected to the quick-freezing process as a means of preservation. Raspberry pulp for jam making is imported in large quantities from abroad, sulphur dioxide being allowed as a preservative in the ratio of 2,000 parts per million.

Strawberries

Strawberries are usually eaten raw with the addition of sugar and cream, when the latter is obtainable, or with ice-cream. The quality of strawberries produced in this country is probably higher than that of similar fruit produced anywhere else in the world. The production of the fruit has developed into a highly-organised industry. Not only are large quantities consumed raw as a dessert but the fruit is also in great demand for preserve manufacture. For the table the appearance, colour and flavour of the fruit is of paramount importance. It should possess a sweetly-acid flavour, while the berries should be of fair size. The fruit is subject to a number of fungoid and parasitic diseases. " Leather jackets " often cause considerable damage to crops. Excessive or strong sunlight will scorch the berries and render them unsaleable, while they are often found in a dirty, sandy condition by reason of their habitat. Strawberries should preferably be washed before being consumed. The fruit requires gentle handling as it is easily crushed and quickly deteriorates, particularly if gathered in a soft, wet condition. Rapid transport is essential if the fruit is to be marketed in a prime condition. Soft or over-ripe fruit should not be packed with sound fruit for transport, otherwise the entire consignment will be rapidly affected. Temperatures in the region of 45° F. are most desirable for successful transport to market ; fruit intended for this purpose should be picked with the stems attached, as removal of the stem during picking tends to accelerate deterioration. Strawberries are also canned, but the high temperatures used for sterilisation alters their appearance, while much of the original flavour is lost. The manufacture of strawberry jam makes use of large numbers of low-grade or small fruit annually. As the fruit contains only a minor concentration of pectin, the jam does not "set" well. For this reason strawberries are often combined with other fruits which contain a higher percentage of pectin. Alternatively, prepared pectin may be added. Strawberries used for preserve manufacture are usually hulled, washed and drained, after which they are packed in barrels with sugar. The barrels of fruit are stored in cold rooms until required, being rolled daily to mix the fruit and the sugar. Large quantities of both fresh fruit and strawberry pulp are imported annually. Sulphur dioxide may be added to the pulp in the ratio of 2,000 parts per million, to act as a preservative. Strawberries are also quick-frozen for future use. A storage temperature of 0° F. is required to prevent deterioration due to enzymic action. Strawberries have a high moisture content but little fat and protein. Their carbohydrate content accounts for most of the total solids contained. Vitamin C makes up the bulk of their vitamin content although traces of vitamins A, B_1 and G are found.

Bottled or Canned Fruits

During the last two decades much more attention has been paid to the canning of fruit in this country, with the result that increasing quantities of home-grown varieties are treated in this way. Many types of canned fruit are preserved with sugar in the form of a syrup ; the bottled varieties are almost invariably packed in water and have to be sweetened before use. The demand for *canned fruit*, particularly canned peaches, apricots, pears and other imported varieties, greatly exceeds the supply at the present time. The majority of these fruits are of excellent quality and provide a significant addition to our available diet, particularly when home-grown fresh fruits are scarce. Fruit selected for canning must be thoroughly prepared. It must be peeled, cored, blanched, washed or merely cleaned, according to the type of fruit being treated. It must be in sound condition and free from bruises. After preparation it is packed in cans, hot light or heavy syrup being added, although in some cases the fruit may be packed in water. The cans are exhausted, the lids fixed and processing is finally carried out, the time required for this purpose depending upon the type of fruit to be treated. After treatment the cans are cooled, dried and labelled. The cans have concave ends after cooling and are usually inspected for leakages by immersion in water. Certain types of canned fruits, particularly those which possess a natural acidity, are liable to take up a certain amount of tin from the container. It has been authoritatively stated that the presence of tin in excess of 2 grains per pound is both unusual and unnecessary and should be viewed with suspicion owing to the irritant nature of the metal. It is not possible to be dogmatic on this point, however, as the exact degree of contamination which would render the fruit unsafe for use is difficult to assess.

Bottled fruit is usually more expensive. The consumer is often quite prepared to meet the increased price, as it is believed that danger from metallic contamination of the contents is obviated. This, of course, is true, but bottled fruits have other advantages. Vacuum-sealing apparatus is not required, while the condition of the contents is visible at a glance. Glass containers are more expensive, however, and more easily broken, while the possibility of glass splinters obtaining entrance to the contents must not be overlooked. The fruit to be bottled is cooked and placed in the container, which is sealed with a metal cap provided with a rubber washer, this forming an efficient seal. The contents remain sterile for reasonably lengthy periods, dependent, of course, upon the temperature of storage. Prior to the War it was the practice of some wholesale dealers to transfer choice canned fruits to glass containers to be sold at an enhanced price as bottled fruits.

Dried Fruits

Large quantities of dried fruits are consumed annually, the bulk being imported from abroad. *Apples* are dried in the form of sections, but more usually in rings. Excessive storage causes the dried fruit to turn brown, when the fruit will ferment and gradually shrivel. Sulphur dioxide in the ratio of 2,000 parts per million is allowed as a preservative. When *apricots* are dried, the fruits are halved, stoned, sulphured and dried. Dried apricots will retain their colour for two years. The dehydration process will extract approximately 80 per cent. of the moisture content. The fruit should be firm to touch and have a bright appearance. When damaged by water, apricots are soft and spongy. They should not be mouldy, maggoty or sugary. Sulphur dioxide in the ratio of 2,000 parts per million is allowed as a preservative. *Currants* are produced by drying special types of small black grapes, grown especially in Australia and Greece. They are often in a dirty condition when received. When tested by the handful they should emit a dry, pleasant smell. Fermentation readily supervenes when they become damp ; grubs are often found in Australian currants. Their presence is due to moths which lay their eggs in the fruit. Despite variations in temperature, the eggs hatch out during transit to this country. Good-quality *dates* are large, soft and moist. They are usually packed in small boxes, the poorer varieties being packed in large wooden boxes. Pressed dates often become dry and sugary. They will ferment when damp and become soft, emitting an alcoholic odour. If allowed to become sticky or wet, mould growths will develop. During warm weather they often become infested with insects, while infection with date smut will cause the entire mass to become powdery. *Figs* are a popular variety of dried fruit. The best grades come from Turkey. They should be dry but soft on the outside while being soft and luscious internally. Their texture should be firm but not rough. If properly dried they will keep for long periods. During storage they often become encrusted with sugar crystals on their external surfaces. If stored too long the dried fruit turns black. Figs are affected with a form of smut similar to that which affects dates. They are difficult to keep free from maggots and worms. Several boxes should always be examined, as the packers sometimes place the larger figs on the top layers and the inferior fruits, which are known as "naturals," lower down. *Prunes* are plums from which the stones have been removed. They are oven-dried. When stored for lengthy periods they become very dry and exhibit a white appearance. Under suitable conditions their maximum storage period is approximately three years. After long storage they are frequently steamed in order to refresh them and to render them more saleable. *Raisins* are sun-dried or dehydrated black grapes. Large quantities are imported from Australia, Spain and California, the latter types being the seedless varieties. Seedless raisins tend to crystallise and exude grape sugar. There are several varieties of raisins, the Muscatel type being used as a dessert fruit. Other varieties are used for confectionery and the production of various sweets. They readily ferment if stored under damp conditions and are liable to infestation by worms and maggots. Sulphur dioxide in the ratio of 750 parts per million may be used as a preservative. *Sultanas* are pale golden raisins produced from white seedless grapes. They should be even in size and should be free from black or red berries, stones, seeds or kernels. They should not be sticky. The skins should be delicate and thin. The fruit is generally free from maggots and worms, being usually treated by means of a special dipping into a boiling alkaline solution which cracks the outer skins and allows them to dry. Immersion in the boiling solution kills all forms of insect life. Sultanas will ferment quickly if stored under damp conditions. Similar preservatives are allowed as for raisins. *Peaches* and *pears* are also dried for sale. Preservatives may be added as for apricots. Prior to the War large quantities of dried fruit, particularly raisins and sultanas, were obtainable packed in cartons. It is to be hoped that sales in this form will soon be resumed. Dates and figs are now frequently sold in cellophane wrappings.

Crystallised Fruits

The bulk of crystallised fruit used in this country is imported from abroad. Such fruit consists either of whole fruit or sections which have been boiled in syrup and allowed to cool and dry, the sugar forming crystals both in the fruit and on its external surfaces. If stored in a cool atmosphere, the keeping qualities are excellent. Sulphur dioxide is allowed as a preservative in the ratio of 100 parts per million. Although not coming strictly within the category of crystallised fruit, *toffee apples*, which are extremely popular with children, might be mentioned. These are manufactured from uncooked apples which are dipped into liquid toffee. The toffee solidifies on cooling. Small green cooking apples are often used for this purpose. Some of these apples are frequently infested with maggots. The price usually charged is out of all proportion to the cost of production or the food value of the article.

Nuts

Nuts form a popular article of diet, particularly among vegetarians. While they are extremely nutritious, they tend to be indigestible. The common varieties offered for sale are almonds, Brazils, chestnuts, coco-nuts, filberts, hazel nuts, peanuts and walnuts. All the varieties listed above form a valuable additional source of food. Nuts are extremely rich in protein and fat, their oily content enabling them to resist fermentation. Their protective shells make it possible for them to be stored for long periods. The oil which they contain causes them to be subject to rancidity, when they will possess a soapy taste, eventually turning black and drying up. For this reason old nuts may be extremely unwholesome. When sound, nuts are heavier than when bad. If it is discovered that the bulk of any consignment is unsound, the whole should be condemned. Thin-shelled nuts are most often found to be unfit for human consumption. All nuts are affected by damp storage conditions ; weevil infestations often cause considerable damage, especially to filberts, by eating their way into the interior of the kernels. Besides being eaten raw, nuts are also cooked, as in the case of chestnuts, and form an ingredient of various types of cakes and sugar confectionery. Ground-nut cultivation is being intensified in order to increase the amount of oil available for the production of margarine. Up to date these efforts have met with little success, but operations are being reorganised with a view to improvement resulting in this direction. Nuts are often sold in a ground condition, e.g. almonds, while they may be chopped or roasted. Many types of nuts are now retailed in packaged form and are quite commonly wrapped in cellophane wrappers, a form of treatment which prevents their being affected by damp and thus deteriorating.

Composition

Fruit generally possesses a high moisture content, which varies between 80 and 90 per cent. of the whole. A certain percentage of fibre, carbohydrates, minerals, vitamins and organic acids, together with a limited quantity of fat and protein, are also found. Although these main constituents are always present, the amounts are not constant, even in a particular type of fruit, since soil, climate, rainfall and other physical conditions affect the final composition. The banana is the only fruit which contains starch. This constituent is converted into carbohydrate or sugar during the ripening process ; most of the carbohydrate found in fruit is present in the form of utilisable sugar. Raspberries, bananas, currants and grapes contain the greatest quantity of *protein*, the percentage varying from 1·3 to 1·7 per cent. ; apples contain the least (0·4 per cent.). Fruit is not a plentiful source of *fat*, although raspberries and grapes contain between 1·0 and 1·6 per cent., the lowest percentage of this substance being found in bananas, peaches, oranges and plums (0·2 per cent.). All fruits contain a certain amount of *mineral matter* in the form of potassium. The mineral content is similar to that of vegetables (see p. 363). Fruit always contains calcium, phorphorus, manganese, iodine and iron, but to a lesser degree than do vegetables. A small proportion of mineral matter is lost during cooking, but is contained in the juices which are usually consumed with the fruit. The *carbohydrate content* is present in two forms. What is termed the *unavailable carbohydrate* consists of roughage in the form of cellulose and pentosans. This may form the bulk of the substance and is of little value as regards the production of energy. The remaining *available carbohydrates* are sucrose, sugars and starches. The roughage provided by the unavailable carbohydrate is unassimilable and acts as a laxative owing to its power of absorbing water and introducing bulk into the intestines. It is much less irritant than cereal fibres. Most fruits contain the carbohydrate pectin. This is present in varying quantities, according to the type of fruit. Fruit, especially grape-fruit, oranges and lemons, are good sources of *vitamins*.

Vitamin C is present in most abundance, while many varieties contain reasonably high percentages of vitamins A and B_1. Vitamin G is also present in small amounts in many fruits. Vitamin A, together with the carotene content, is insoluble in water and is not lost when fruit is stewed or cooked in water. This vitamin is, however, liable to destruction by oxidation, although the usual methods of cooking are not likely to exert an adverse effect. Vitamin B_1 (thiamin) is soluble in water. In the acid environment in which fruit is normally cooked thiamin is resistant to the effects of heat. Unless the juices are discarded after cooking, little will be lost. Vitamin G (riboflavin) and nicotinic acid, together with its derivatives, are soluble in the cooking water but are relatively stable in an acid medium at the temperatures normally employed in cooking. The vitamin C content is oxidised readily in an alkaline medium and in the presence of metals, particularly copper. A rapid rise in temperature, e.g. when fruit is boiled, will destroy the ascorbic acid oxidase. The *acid content* is present in the form of citric acid (oranges and lemons), malic acid (apples, peaches and plums) and tartaric acid (grapes). The *flavour* of fruit is produced by the sugars and acids contained, together with certain essential oils and compound ethers, which also impart an agreeable odour.

Nutritive Value

Fruit is one of the *protective foods*, furnishing many nutrient substances, particularly vitamins, now universally recognised as essential to human nourishment. This is particularly so in regard to minerals and vitamins necessary to the average diet, which so often contains an excess of starchy foods. The consumption of fruit assists in the correction and prevention of various forms of anæmia, dental caries and diabetes. Most fruits exert a beneficial influence upon the digestive functions, together with a mild laxative effect. Fruit which is to be eaten in a raw condition should be ripe, free from decay and not infested with insects. Unripe or immature fruits are not wholesome. If infested with insects, their eggs may be the means of introducing the larvæ into the digestive tract of the consumer. It is reported that the food value of fruit which has been sprayed with arsenical preparations is considerably reduced.

Epidemiology

Fruit has rarely been incriminated in disease outbreaks, although the current practice of exposure for sale may cause contamination with dust from the streets, animals or insects. The degree of handling which fruit receives at the hands of the vendor may further result in infections of various types being passed on to the consumer, especially if the fruit, as is very often the case, is eaten in a raw condition. The possibility of serious infection in this way should therefore not be overlooked. The possible infection of fruit with intestinal organisms is important. These organisms may remain viable on unbroken fruit skin although, usually, they are quickly destroyed when exposed to acid juices. Flies may also infect fruit, while it has been reported that tubercle bacilli have been isolated from grapes handled by infected persons. Experimentally it has been found that the organisms of cholera, dysentery and typhoid fever can exist for several days on the skins of fruit. The presence of pathogenic organisms on fruits exhibited for sale has occasionally been demonstrated, while non-pathogenic intestinal organisms have often been discovered. An outbreak of dysentery due to *Shigella Sonnei* was reported in 1948 from Hornchurch, affecting 121 school children. Stewed apples were circumstantially involved as the medium for the spread of the disease. The method of infection was not ascertained.

The presence of spray residues from solutions used in spraying the trees or bushes during growth may also be detected. To increase the adhesive powers of the spraying liquids, ingredients such as casein and oil are often incorporated. The residues from sprays of this type are not easily removed. As fruit is often consumed by patients or by invalids the problem assumes greater importance, as the resistance of such individuals to any form of infection will be greatly reduced. Arsenic and lead have been found in considerable quantities on apples exposed for sale. Serious illness and even death has resulted from the consumption of fruit containing such residues. Quite recently, imported Italian pears were found to be contaminated with arsenic and copper from insecticidal sprays. For this and other reasons all fruit eaten raw should be carefully wiped with a clean damp cloth as a precautionary measure. The whole question of sprays and their residues requires investigation in the interests of public health. The increasing use of ethylene gas to accelerate ripening of fruit and to improve its colour and quality was at one time thought to affect the fruit so treated in an adverse manner. From the public health point of view, however, no danger would appear to exist with the quantities or concentrations at present employed. The consumption of fruit treated in this manner has never been shown to be the cause of illness. Dyed fruit may be dangerous, and this process should be stopped. Cases of dermatitis have been reported where persons have handled fruit treated in this manner.

Control

From a public health standpoint, efficient control should be exercised to ensure that the handling and sale of all fruits is carried out under suitable conditions. The fruit itself should be inspected for soundness to ensure that decomposed produce is not sold, that it is not infested with insects, that artificial colouring matters have not been used, that it is free from insecticidal residues and that hygienic methods of handling are practised. It is important also that the stock should be displayed at a sufficient height above ground level to ensure that it is not in danger of contamination by prowling animals or by human expectorations. The surroundings of the display should be clean and sanitary, especially if the fruit is exposed for sale on the open market. The fruit should also be protected from dirt, particularly if display is carried out in the open air. If fruit is infested with grubs or insects or if it is partially or wholly decomposed or otherwise contaminated, it should be seized and destroyed. Adequate hygienic measures and their application to the control of fruit are important, as much of this commodity is eaten in its raw state, particularly by children. For this reason the methods employed in the sale of fruit from small shops and street barrows or stalls call for the exercise of stringent control measures at all times.

CHAPTER XXIII

VEGETABLES

VEGETABLES of various kinds, particularly the green varieties and certain roots such as potatoes, are important constituents of the human diet in every part of the world. Numerous types are obtainable, some of which are eaten raw, as in salads, while others are cooked in various ways and consumed in company with meat, fish or fowl dishes. Many individuals eat very little food other than vegetables and suffer no ill effects, so that it is true to state that vegetables form an adequate diet if suitably chosen from the innumerable varieties available. During the last twenty years vegetables of all kinds have become increasingly popular, doubtless due to the repeated urgings of dieticians as to their food value and the realisation that proper cooking will render vegetables more appetising as well as preserving their nutritive value. The vegetable industry in this country has developed rapidly, although large quantities are still imported annually, particularly from the Continent, often to the detriment of the home producer.

The culture of vegetables is widespread, particularly in temperate and sub-tropical zones. Soil and climatic conditions, such as rainfall, temperature, quantity and quality of sunlight and length of the growing season, are important factors. Vegetables suffer from a number of plant diseases and fungi, which may render them unfit for human consumption. Bruised or damaged products are particularly susceptible to such infections. For this reason vegetables in this condition should not be harvested or packed with sound articles. If this is done the entire consignment may rapidly deteriorate. Adequate ventilation during storage is also important if spoilage is to be prevented. It is important to remember that the normal respiratory processes are carried on by vegetables for some time after they have been gathered. Heat and moisture are liberated during this period, so that when large quantities are packed together there may be a considerable rise in temperature in the interior of the mass. If ventilation is restricted, moisture will be produced. If this is combined with a rise in temperature, spoilage organisms will rapidly develop. The action of enzymes is also accelerated. These assist in producing decomposition. Low storage temperatures are particularly valuable, although varying temperatures are necessary for different varieties. In connection with cold storage of vegetables, mention must be made of experiments carried out in the United States of America in this connection. Ice has been used for this purpose and it has been found that vegetables packed in ice retain their freshness and also their ascorbic acid and carotene values. Tests have been made in this country which show that vegetables packed in crushed ice keep in first-class condition for up to three weeks without loss of weight. Vegetables may be classified into three groups: the *green type*, such as cabbage; *roots and tubers*, of which potatoes are an example; and *pulses*, which include peas and beans.

Green Vegetables

The various green vegetables in common use are possessed of little starchy matter and contain much indigestible cellulose, together with acids and mineral salts. After being gathered they soon lose their freshness, the leaves becoming withered and lank. When fresh they are firm and brittle. They emit an objectionable odour when in a state of decay.

Asparagus

Formerly considered to be a luxury vegetable, large quantities of asparagus are now grown in this country, while much is imported from the Continent. Three types of asparagus are marketed. The green variety is obtained by cutting off the spears at ground level. This type quickly dries out, as it does not possess any of the woody portion, which would assist in preventing rapid loss of moisture. Green asparagus with a white butt is cut by means of a special knife so that a portion of the shoot comes from beneath the surface of the ground. White asparagus, which is in great demand for canning, is grown in darkness by drawing up the soil over the crowns. This variety is cut as soon as the tips of the spears are visible above the surface of the soil. The spears are cut quite frequently, particularly when the weather is warm or if the plant is grown in glasshouses, in order to preserve its tenderness. This is particularly important as the old shoots possess an acrid taste. Damage may occur during growth due to depredations of the asparagus fly and beetle. After cutting, the spears are graded, bundled and stored in a cool place to protect the vegetable from the deleterious effects of excessive heat. The grading varies according to the diameter of the spear. Chemical changes take place in spears during the first day after cutting, particularly under warm conditions. The sugar content is reduced, while there is an increase in the tough fibrous constituents which renders the vegetable less edible. Low temperatures during storage and transport are essential if asparagus is to reach the market in satisfactory condition, since warm air causes the spears to lengthen and chemical changes to occur. Crates used for transport are generally lined with paper. If the asparagus has to travel long distances, damp moss is used, the bundles being packed with the butts downwards. Apart from its normal use as a cooked vegetable, when the tips only are eaten, large quantities of asparagus are canned. A certain proportion is also used in the manufacture of soups. Asparagus is highly regarded as a culinary vegetable owing to its delicate flavour and diuretic properties. Asparagus contains approximately 1·8 per cent. protein, 2·4 per cent. carbohydrate, together with a small quantity of fat (0·2 per cent.) and ash (0·67 per cent.). Green asparagus contains vitamins A, B_1, C and G, whereas the bleached variety contains vitamin C only.

Cabbage

This vegetable belongs to the Brassica family. Under the same heading can be considered all similar vegetables, such as sprouts, kale, broccoli and cauliflowers. All these types are widely grown throughout the temperate zones and are reasonably resistant to frost. With a wider knowledge of nutritional values in relation to food supplies, these vegetables are now recognised as possessing valuable anti-scorbutic properties by reason of their vitamin C content. This is particularly so in the case of their greener leaves, although it should be noted that much of this valuable substance will be lost during cooking if this is not properly carried out. These vegetables should always be eaten when fresh and tender, otherwise they are difficult to digest and may cause flatulence. Not only are these vegetables eaten in boiled form ; certain varieties of cabbage, particularly the red type, are either pickled or used raw in salads, while cauliflower forms one of the main constituents of many types of pickles. A number of insect pests attack the plants. Various sprays, some of which are poisonous to human beings, are used to control or prevent such depredations. The most serious disease is club-root, which spoils the crop and can only be eliminated by the use of seed which is free from infection and by strict rotation in the use of land. These vegetables are also subject to a soft rot of bacterial origin which causes the leaves to turn black or brown. When they have been cut, they soon deteriorate, become lank and quickly rot, so that speedy, cool transport is essential if they are to reach the consumer in prime condition. They are usually packed in network bags. Adequate ventilation should be provided both during transport and storage so that condensation of moisture, which favours decomposition, may be avoided. The odour emitted from vegetables of this type when decayed is unmistakable and is particularly objectionable.

Cabbages have the highest moisture content of the Brassica class (92·4 per cent.) and a carbohydrate content varying between 3·0 and 6·5 per cent. Their protein content averages 1·4 per cent. The mineral matter is approximately 0·75 per cent., with a fat content in the region of 0·3 per cent. The moisture content of broccoli, cauliflowers, kale and sprouts varies between 84 and 90 per cent. of the whole. Their protein content seldom varies (1·5 to 3·0 per cent.) ; the carbohydrate content of sprouts (3·4 per cent.) and kale (2·1 per cent.) is lower than that of broccoli and cauliflowers (3·7 per cent.). The mineral content is approximately the same (1·1 to 1·7 per cent.). Kale and cauliflowers have the highest fat content (0·4 to 0·5 per cent.), against an average of 0·1 per cent. for sprouts. Cabbage contains vitamins A, B_1, C and G ; sprouts, vitamins A, B_1 and C only ; whilst broccoli and kale contain vitamins A, B_1, C and G. The respective constituents and vitamin content of all green vegetables is considerably reduced when the vegetables are stale.

Celery

Because of the method of cultivation and subsequent blanching, celery produces stalks which have lost their acrid qualities and have assumed a sweetish aromatic taste. Celery is greatly appreciated as a salad plant, although in its raw state it is difficult to digest, particularly if excessively fibrous. Celery, both blanched and green, is also used in the production of soups. It is occasionally boiled before being consumed. Both red and white varieties are grown. The latter variety is crisper and more tender and possesses the better flavour. When fresh it appears bright and crisp ; when stale it is usually coarse and stringy. It is sometimes affected with "brown rot," the heart of the vegetable becoming soft, brown and foul smelling. Apart from its moisture content, celery contains protein (1·1 per cent.), fat (0·1 per cent.), mineral matter (1·08 per cent.) and carbohydrate (3·3 per cent.). Vitamins A, B_1 and C are also present, the percentage of vitamin A being considerably higher in the green stalks. Celery hearts are frequently canned. *Celeriac*, or turnip-rooted celery, is cultivated chiefly on account of its roots, although both roots and stalks are edible and are used for salads and soups.

Cucumber

This vegetable is mainly eaten raw in salads, although a smaller type, known as the *gherkin*, is used in the manufacture of pickles. Both hot-house and open-air varieties are grown, the skin of the latter type being rather coarse. The vegetable contains little nutriment but possesses a high moisture content which induces refreshing properties. Care in handling is essential to prevent bruising. Cucumbers, which are not easily digested, will keep for long periods when undamaged, particularly at temperatures in the region of 40° F. Cucumbers contain approximately 0·8 per cent. of protein, 0·2 per cent. of fat and 2·3 per cent. of carbohydrate, together with a large amount of moisture. Vitamins A, B_1, C and G are also present.

Lettuce

This is a popular salad plant grown in large quantities both in this country and on the Continent. Both the hot-house or forced types and the normal outdoor varieties are grown, forcing being essential during the winter months to ensure constant supply. Two species are available, the cabbage type and the cos or straight-leaved lettuce. Lettuces soon deteriorate and should be eaten when fresh, after careful washing. Apart from a high moisture content, lettuces possess small quantities of fat (0·3 per cent.), protein (1·2 per cent.), mineral matter (0·91 per cent.) and carbohydrate (2·2 per cent.). They also contain vitamins A, B_1, C and G. The vitamin A content of the green-leaved type is many times greater than that of lettuces which have been bleached.

Vegetable Marrow

The vegetable marrow is a member of the gourd family. When boiled, marrows are used for table purposes. Both the green and the yellow varieties are in optimum condition when young. They should not be over-boiled during cooking, so that their flesh remains tender and their flavour sweet and nutty. The moisture content in marrows is high, but they will store for an appreciable time if decay is not accelerated by bruising when handled. They are subject to a disease known as " brown heart," which causes the core to become unsound. Marrows contain approximately 0·7 per cent. of protein, 0·1 per cent. fat and 1·5 per cent. carbohydrate. *Pumpkins* are yellow or orange-coloured globular vegetables with a reasonably smooth rind, the smaller varieties being most esteemed for boiling or baking or for manufacture into pies mixed with fruit or other ingredients. When small or green, they are eaten like marrows. Their moisture content is high, but if carefully handled, so that their skins are not damaged, pumpkins will store for months under suitably dry, warm conditions. The protein content averages 1·0 per cent., while they may contain 0·1 per cent. fat. The carbohydrate content ranges from 3·0 to 14·0 per cent.

Onions

Onions are in considerable demand for inclusion in salads, for flavouring various dishes, for pickling and for soups. Salad or spring onions are gathered when young, green and immature ; those used for pickling are special varieties. When mature, onions are harvested. They should be thoroughly dried and stored so as not to be affected by frost or damp. Before they are fit for storage, onions should be cured or dried. Care in this process is necessary, as the onions emit moisture which must be free to evaporate, otherwise they may rapidly decompose. During storage, low temperatures and adequate ventilation are extremely important. The ideal storage temperature is approximately 32° F., low temperatures being important if sprouting is to be avoided. If the temperature is too low, however, the onions will freeze. The air of the store should be dry ; careful regulation of the ventilation is essential.

Onions have a high moisture content, although when in good condition they are firm and hard, their moisture content being most in evidence when they are decomposed. When decomposed, onions become soft and pulpy. Attacks by the onion fly will cause rapid decomposition, while a soft rot develops in bruised onions due to bacterial development. Onions have a characteristic odour and flavour, due to the allyl sulphide content. They have modified medicinal properties. Onions have been frequently dehydrated into a powder which is used as a flavouring material in various types of soups and stews, while their protein content averages 1·6 per cent. The fat content is approximately 0·3 per cent. and the carbohydrate present varies between 4·0 and 14·0 per cent. Vitamins B_1, C and G are present in small quantities. Leeks, shallots and chives, which are akin to onions, are also grown in large quantities. The *leek* has properties very similar to those of the onion but is of a milder type. The entire plant, with the exception of the fibrous roots, is used, being boiled as a vegetable or incorporated into soups or stews for flavouring purposes. The stems are usually blanched. The protein content of leeks averages 1·2 per cent., the fat content 0·5 per cent. together with 5·8 per cent. carbohydrate. The main vitamins are B_1 and C, although reduced amounts of vitamin A and G are also present. The *shallot* is a hardy bulbous vegetable which is eaten in salads in its green immature state or, when ripe, used for pickling. *Chives* are a perennial form of spring onion which continue to reproduce during the growing season. They form a useful constituent of winter salads.

Rhubarb

This vegetable is mainly raised from crowns or roots. Large quantities are sold annually for culinary purposes, being used either stewed in a similar manner to fruit, or in pies, when suitably sweetened with sugar. During the early months of the year large quantities are forced. When treated in this way, the moisture content is higher and the nutritional value lessened. Only the familiar red stalks are eaten, the leaves being exceedingly poisonous. Rhubarb contains large quantities of oxalic acid in its juice and is quickly injured by frost. It is also canned in syrup for future use. Rhubarb contains approximately 0·6 per cent. protein, 0·7 per cent. fat and 2·5 per cent. carbohydrate. Vitamin G is present in fair amounts.

Spinach

This vegetable is appreciated for its succulent leaves, being wholesome and easily digested. In common with all green vegetables, it emits an offensive odour when in a state of decomposition. Spinach is often canned, particularly in the form of what is termed strained food (see p. 402). A little colouring matter may be added, while spinach puree should contain not less than 0·1 per cent. and not more than 0·6 per cent. of salt. Its leaves contain large quantities of chlorophyll. Apart from its moisture content (92·7 per cent.), it contains approximately 2·1 per cent. protein and 2·3 per cent.

carbohydrate, together with smaller quantities of mineral matter (1·5 per cent.) and fat (0·3 per cent.). It contains more vitamin A than any other vegetable, while vitamins B_1, C and G are also present.

Watercress

This vegetable is grown in beds which are established in shallow running water. In a wild state it is often found growing in watercourses. Watercress beds are usually arranged at different levels so that the water from the highest bed may overflow to those below. In winter the beds must be protected from frost. The vegetable exhibits optimum flavour when grown in water which has flowed over chalk or gravel. If grown in stagnant water, a brown jelly-like substance will be found on the stems of the plants. Watercress is usually eaten raw, either alone or in salads. It has a pungent though pleasant flavour, due to its essential oil, which contains sulphur. It also has a substantial medicinal value. As watercress is eaten in its raw state, the purity of the water is of considerable importance. If the water is polluted with sewage the plants absorb some of the impurities present, while solid particles are likely to adhere. These are difficult to remove during subsequent washing operations. Watercress may thus become a dangerous food from the public health point of view. Outbreaks of typhoid fever have resulted from the consumption of polluted cress. Regular bacteriological examination of the water used should be carried out to ensure absolute purity. Its protein content averages 0·7 per cent. with a fat content of 0·5 per cent. and 3·7 per cent. carbohydrate. Watercress contains vitamins A, B_1, C and G.

Roots and Tubers

This class of vegetables, of which potatoes and turnips are among the commonest types, is grown for its roots, which develop underground. Roots and tubers usually contain large quantities of starch, which is convertible into sugar, a typical example being the beetroot. Their moisture content is high but they will keep well under suitable storage conditions.

Artichokes

Two types of artichokes are available for human consumption. The common type, which is eaten raw, boiled or as a constituent of soups, bears some resemblance to a large thistle. The common artichoke contains 2·6 per cent. protein, 0·2 per cent. fat, and 15·9 per cent. carbohydrate. The Jerusalem artichoke is cultivated for its tubers, which are eaten like potatoes. These tubers are rich in the carbohydrate, inulin, and sugar. This type of artichoke contains 2·9 per cent. protein, 0·1 per cent. fat and 16·4 per cent. carbohydrate.

Beetroot

This vegetable is cultivated mainly as a salad plant, being first boiled and thereafter consumed cold. It may also be pickled, while the tubers are occasionally eaten as an ordinary vegetable. Both round and long beetroots are available. Care must be exercised when the beetroot is gathered so that the tuber is not bruised. The tops should be twisted off, and never cut. If these precautions are ignored the roots will bleed and lose their uniform deep red colour. When old, beetroots are extremely hard or "woody," in which state they are very indigestible. Beetroots are highly nutritious, containing besides approximately 87·6 per cent. of moisture a reasonable quantity of carbohydrate (10·0 to 16·0 per cent.), together with 1·6 per cent. protein, 1·11 per cent. mineral matter and a small quantity of fat (0·1 per cent.). They have a low vitamin content, only small quantities of vitamins B_1, C and G being present.

Carrots

The carrot is an orange-coloured vegetable, obtainable in both the long and short types. The roots are often spoiled by the larvæ of the carrot fly and do not store very well, being apt to become soft and mouldy. In sound condition carrots are nutritious. They are used in a boiled condition, in stews or raw in salads. Their moisture content is approximately 88·2 per cent. They contain a reasonable quantity of carbohydrate, approximating to between 5·9 and 11·5 per cent. Their fat content (0·4 per cent.) is low. They possess some 1·1 per cent. protein and 1·02 per cent. mineral matter. While including small quantities of vitamins B_1, C and G, the carrot is most valuable for its high vitamin A content, particularly when consumed in a raw condition.

Parsnips

Parsnips have been cultivated for hundreds of years because of their long, fleshy white roots, which have a peculiar yet agreeable flavour. The texture of the root is very coarse. The roots contain large quantities of starchy matter. Parsnips are most nutritious when young, as the older roots often become hard or "woody," in which state they are indigestible. These vegetables contain 1·6 per cent. protein and 0·5 per cent. fat, while the carbohydrate content varies between 6·0 and 14·0 per cent. They contain a fair amount of vitamin C, a small quantity of vitamin B_1, but no vitamin A or G.

Potatoes

The potato is almost certainly the commonest and most valuable vegetable grown and used throughout the world. This is undoubtedly so in this country, since, in addition to home-grown potatoes, large quantities are imported annually from abroad, particularly the early varieties. There are innumerable types of potatoes, most of which are subject at one time or another to numerous diseases and insect infestations. Grubs and wireworms are almost always present, while eelworm infestations are also common. During the last few years careful watch has had to be kept in order to prevent attacks by the Colorado beetle, which can be extremely destructive and result in the total loss of the crop. These insects destroy the foliage and are usually controlled by spraying with Bordeaux mixture, Paris green or other arsenical compounds.

The numerous diseases from which potatoes are likely to suffer will also result in considerable loss if not controlled. *Dry* or *wet rots* may develop due to the action of fungi, while *winter rot* is common. The surface of the affected tuber shows depressions. Portions shrivel, while the whole is covered with patches of fungus. While the substance is reduced to a soft fœtid mass, the skin remains intact. A common fungus disease is *blight*, or potato scab. This affects both the tops and the tubers. It is a common disease, patches or scabs appearing on the external surfaces. The market and not the food value is mainly affected. *Corky scab* is a parasitic disease which is localised into small dark-coloured, slightly-raised patches on the surfaces of the tubers. These rupture, a dense mass of brownish or snuff-coloured spore balls becoming exposed. *Potato disease* primarily attacks the leaves, travelling to the tubers by means of the stem. Brown spots appear on the surface of the potato, which finally rots. *Wart disease*, also known as black scab, is evidenced by warts or wrinkles found near the " eyes " of the tubers. They coalesce to form a brown spongy scab, the potatoes finally becoming black and unwholesome.

When harvested, potatoes should be dried before they are stored. Deterioration may be prevented in this way without serious shrinkage by the use of temperatures in the region of 50° F. Low temperatures, and particularly frosts, are extremely dangerous and cause decay and rapid deterioration. After drying, potatoes are usually graded and bagged for transport. During storage changes gradually occur, as the potatoes breathe and emit carbon dioxide, this process being favoured by warmth. If conditions are excessively dry the potatoes will shrink, due to the evaporation of a portion of their moisture content ; damp conditions together with warmth will cause them to rot. The optimum storage temperature varies between 33° F. and 40° F., combined with a humidity of approximately 85 to 90 per cent. While damp storage conditions must always be avoided, humidity plays an important part in the storage of potatoes. It should be sufficient to avoid any loss of moisture from the tubers while being insufficient to cause deterioration.

When stored, potatoes should not be stacked in excessively large heaps. Such heaps should not be more than 6 feet in depth, so that the carbon dioxide produced may be rapidly dissipated. So far as is practicable, light should be excluded from storage rooms, otherwise the tubers will begin to sprout and their nutritive qualities will be injured. All potatoes which are to be stored should be dry and sound. Potatoes stored at temperatures below 50° F. tend to increase their sugar content at the expense of the starch percentage. Because of this tubers which have been stored for lengthy periods may be discoloured in cooking, owing to caramelisation of the sugar. Darkening during cooking operations is said also to be due to the presence of tyrosine and other amino-acids. In such potatoes the protein content is unstable and readily hydrolysed. It is reported that a low potassium content in the soil is the main cause of this defect.

When sound, the flesh of the tuber should be clear and firm and of even density. It should separate crisply when cut, while good " cookers " will cling to the knife during this operation. The moisture content of potatoes is approximately 77 per cent., and they contain a large proportion of carbohydrate (18·0 per cent.) in the form of starch. Their protein content is in the region of 2·2 per cent. ; they are low in fat (0·1 per cent.) and mineral matter (0·99 per cent.). They contain vitamins A, B_1, C and G though their vitamin content is reduced by storage. The white flesh of the potato is surrounded by a greenish layer which contains many of the mineral salts, chiefly potassium. These are lost if this layer is removed with the skin prior to cooking.

Small, irregular potatoes not suitable for normal retail sale are used for manufacturing purposes and for cattle food. *Potato crisps* are a good selling product at the present time, the potatoes being thinly sliced after the skin has been removed. The slices are fried in fat until they are crisp, after which they are dried and packaged. *Potato flour* is also produced by means of dehydration, a flour of fine texture being obtained which has been combined with wheat flour for the production of bread and, in Scotland and the north of England, potato scones. It has also been produced for reconstitution into mashed potatoes by the addition of water, the whole being boiled. This latter substance is sold under a variety of proprietary names.

Radishes

These popular salad vegetables possess a pungent taste, have a high moisture content and contain little nourishment. Radishes are readily affected by frost and soon decompose. When old they are " woody " and extremely indigestible. Radishes have a carbohydrate content varying between 2·7 and 7·5 per cent., while fat (0·1 per cent.) and protein (1·3 per cent.) are also present.

Turnips

Turnips are grown for their fleshy roots, which are boiled before consumption. Their leafy tops are also used as a green vegetable. Various varieties are available, the flesh being either white or yellow. The yellow-fleshed varieties are more robust, contain more nutriment and are less likely to be injured by frost. All turnips contain a pungent oil, but their nutritive value is generally low. As with all vegetables, their moisture content is high (90·4 per cent.), while they contain carbohydrate (2·3 to 18·0 per cent.), a very small quantity of fat (0·2 per cent.), 1·3 per cent. protein and 0·73 per cent. mineral matter. The white variety contains no vitamin A, but this vitamin is present in the yellow-fleshed type. Although vitamins B_1, C and G are present in both types, the vitamin value is comparatively poor. The green turnip tops are, however, well supplied with vitamins, particularly with vitamin A. When old, the flesh is coarse and " woody " ; " black rot " causes the roots to deteriorate. *Swedes*, which are a large variety of turnip with pink flesh, are more nutritious when boiled. They keep better than do turnips during the winter months.

Pulses

These vegetables are members of the leguminous family and are notable on account of their high protein content. They are characteristic in that their fruit is contained in pods, from which it is usually removed prior to consumption, the only exceptions to this practice being French and runner beans, where the pods and their contents are eaten together.

Beans

There are several varieties of beans. The *broad bean* is a common type with large, flat nutritious seeds. The pods are inedible unless eaten in an immature state. Normally the seeds are removed from the pods and boiled to provide a wholesome food, although digestion is difficult if the beans are allowed to become old during growth. A popular variety is the *French* or *kidney bean*, which in this country is eaten almost exclusively in its green state, the whole pod, together with the seeds, being consumed as a table vegetable or prepared as a pickle. These beans are nutritious and may be preserved in salt for lengthy periods. When required for use, beans of this type which have been treated by salting must be well washed before boiling.

They then form a useful addition to the diet, particularly when fresh vegetables are scarce. Large quantities of this variety are also canned for future use. The *runner bean,* which is much larger than the French bean although akin to it, is treated in a similar manner. Canned runner beans may contain a little colouring matter. *Haricot beans* are exceedingly nutritious and are usually sold in a dried state to be boiled before use. They are sometimes canned, a little colouring matter being added. They are small in size, white in colour and are rich in protein and starch besides containing a small quantity of fat. Large consignments of haricot beans are canned in tomato puree, being sold under the name of *baked beans* to be used in the constitution of hors d'œuvres or warmed as a vegetable or savoury. The beans are boiled, steamed or oven-baked. In addition to tomato puree, sugar, flour and spices or other seasonings are added. The canned product must contain not less than 5 per cent. of sugar by weight, expressed as invert sugar, and not less than 28 per cent. solid matter when dried for sixteen hours at 98° C. *Butter beans* are similar to the haricot variety in appearance but are much larger. They are usually sold dry but are also obtainable in canned form, a little colouring matter being added. All beans are nutritious, containing a high proportion of nitrogenous matter in the form of legumin. Digestion is, however, difficult. They possess a high nutritive value when dried because of their concentrated carbohydrate and protein contents, while the vitamin content varies with the type of bean. Large quantities of these pulses are imported annually into this country. While they are often gathered for immediate consumption in an unripe or green condition, they gradually dry if allowed to ripen on the plant and can be stored for long periods if maintained in a dry condition. Like most vegetables, they are subject to attacks by maggots during growth, while blight, rust, flies and mildew are present on occasion.

The *soya bean,* which is grown extensively in China and Japan, forms an important article of food in those countries. Soya beans have a bitter flavour, quite different to that of ordinary beans. Taste has to be acquired. They are, however, highly nutritious. When dried their protein content is high (30 to 50 per cent.), while they contain very little moisture (8 per cent.) when compared with other vegetables or pulses. The average fat content is also high, approximately 13 to 24 per cent. of the whole. In addition, they contain a reasonable quantity of mineral matter (9·6 per cent.) and carbohydrate (7 per cent.). The starch content varies between 4 and 9 per cent. They are excellent sources of vitamin A and include a substantial percentage of vitamins B_1 and G together with a lesser proportion of vitamins C and D. The value of the soya bean has now been recognised by Western nations, the bean being used for a variety of purposes. The green beans are canned, used in salads, or eaten when boiled as a green vegetable. When dried they form a useful constituent of soups and breakfast foods. They can also be roasted to form a coffee substitute and are used in sauce making. Ground into flour, they are employed in ice-cream and chocolate manufacture, while they may be mixed with wheat flour in bread or cake manufacture. Soya flour should contain more than 9 per cent. of fat. Soya beans have been soaked in water, macerated and boiled in the proportions of 3 parts of water to 1 part of the macerated mass. This yields a dense liquid which, after straining, has the appearance of cows' milk. This liquid is spray-dried to form a white powder which has been used for infant feeding and for ice-cream manufacture as a constituent of ice-cream powders.

Lentils

Lentils are an orange-coloured pulse, dried before sale, which are usually obtainable with the appearance of split peas without the seed coating. Considerable quantities are imported annually from abroad, to be used in the production of soups and stews. They should have a fresh appearance and uniform colour. During storage they may become infested with weevils, when they will agglutinate. Lentils contain approximately between 25·7 per cent. legumin or nitrogenous matter, 1 to 2 per cent. fat and 50 to 60 per cent. carbohydrate. They are richer, therefore, than any other type of pulse, but require lengthy cooking if they are to be readily digestible.

Peas

Peas are probably the most highly regarded of all the pulses from a dietary point of view, food value and palatability having been recognised for centuries. Not only are large quantities sold in the pod, to be shelled for immediate use, but a considerable trade is carried on in canned, dried and quick-frozen peas for future consumption. When in the pod, peas quickly become slimy and rot, particularly if picked when wet or stored under damp conditions. Two varieties of peas are grown for table use, a *dwarf type* and the *climbing variety*. Some types have smooth seeds ; others possess seeds with a wrinkled appearance. During growth peas are subject to attacks by maggots, to a number of fungoid diseases and to blight. Table peas in the pods are picked by hand. When required for canning or drying, they are harvested and threshed. Round blue peas are dried normally, while the marrowfat varieties, when dried, have a shrivelled appearance. They can be stored, when dry, for periods up to two years, but their colour changes to yellow following long storage. In green condition picking at the correct time is important as, after the pods have been removed from the plant, rapid chemical changes occur. The starch content is then increased, while there is a decrease in the soluble nitrogenous content and in the sugar concentration. For this reason peas should be consumed as soon as possible after picking. As shelled peas deteriorate more quickly than peas which are allowed to remain in the pod, rapid canning is essential. Canned peas must be packed in a liquid containing not less than 2·3 per cent. by weight of cane or beet sugar and not less than 1·25 per cent. and not more than 2·5 per cent. by weight of salt. A little colouring matter may be added to canned peas. Peas are extremely nutritious, containing more sugar than beans, the carbohydrate content ranging between 7 and 16 per cent. The moisture content is approximately 77·8 per cent. when in the green state. They contain very little fat (0·1 per cent.), a reasonable quantity of protein (4 to 6 per cent.) and approximately 0·99 per cent. of mineral matter. They have a high vitamin A content, contain vitamins B_1 and G and they are a good source of vitamin C. This latter vitamin decreases in quantity as the peas reach maturity, diminishing rapidly within a few days unless the peas are stored under cool conditions.

Split peas should appear fresh and polished with a complete absence of holes in the substance. They quickly become mouldy or musty if stored under damp conditions.

Tomatoes

Although doubts have been expressed from time to time as to whether the tomato is a fruit or a vegetable, most authorities seem to agree that it is a vegetable. It will, therefore, be considered under that heading. Large quantities of tomatoes are grown in this country each year, mainly under glass ; small quantities can be grown out of doors in the southern counties. The outdoor type does not possess the fine flavour characteristic of those grown in glasshouses. Still greater quantities of tomatoes are imported annually from abroad, particularly during the winter months and in early spring. Tomatoes are in great demand, not only for table use in a raw, ripe condition and in salads, but also for soups and sauces, for canning, either as pulp or in the form of juice, and for the production of puree. When green and unripe, tomatoes may be manufactured into chutney. The tomato has a high moisture content (94·1 per cent.) and contains approximately 0·9 per cent. protein, 3·3 per cent. carbohydrate, 0·4 per cent. fat and 0·57 per cent. mineral matter. It has a delicate pulp which contains malic acid, a rich vitamin A content, and also vitamins B_1, C and G. The green tomato has a lower vitamin content, vitamin G being entirely absent. When ripe, both red and yellow varieties possess a characteristic flavour, a colourful appearance and health-giving properties.

During growth the tomato is subject to numerous diseases, many of which make their appearance during transport of the fruit to market. The most important of these are a fungus disease known as *black rot*, which produces sunken patches coated with black mould, and *black heart*, in which blackening of the fruit commences round the stalk and eventually penetrates to the centre of the fruit. The latter disease affects tomatoes which have been subjected to lengthy cold storage. *Brown patches* sometimes appear on the skins. The flesh is eaten into and rapid decomposition results. Tomatoes are easily bruised or damaged during handling or transport. Such fruit quickly decays. After picking, tomatoes are usually sorted and graded for size, colour, ripeness and quality. If selected for transport over long distances, they must be carefully packed. While ripe tomatoes are required for table use and for canning, they are usually picked in a partially-ripe condition to prevent over-ripeness when delivered to the consumer. Tomatoes are not well adapted to extended cold storage, although when fully ripened they may be stored at temperatures in the region of 50° F. to 55° F. Higher temperatures of 60° F. to 70° F. may be employed, if desired, to ripen fruit during storage. If higher temperatures are employed the fruit quickly becomes over-ripe and rapidly decays. Low temperatures, of approximately 40° F., are useless if green tomatoes have to be ripened. When ripe, temperatures of 32° F. to 33° F. may be used for short periods of storage. Ethylene gas storage has been employed for the dual purpose of keeping and ripening. This process is not, however, extensively used.

Mushrooms

A number of edible fungi are available for consumption, of which the mushroom is the most important and best known. This fungus contains a high percentage of moisture (91·1 per cent.), 3·5 per cent. protein, 6 per cent. carbohydrate and approximately 0·4 per cent. fat. Some individuals are allergic to this fungus, a form of urticaria supervening soon after mushrooms have been eaten. The mushroom, which has a pleasant earthy odour, must not be confused with the many poisonous fungi which it resembles. Edible mushrooms possess liver-coloured gills and have a concave upper surface covered with white velvety skin which can easily be removed. The flesh is compact, brittle and slightly moist. Poisonous fungi are pale brown in colour, possess a soft flesh, are slightly fibrous and have pale gills. When cut or broken, a milky fluid is exuded. Stale mushrooms are dull, have no fresh smell, possess a bitter taste and are soft and watery. They are sometimes infested with maggots. Both wild and cultivated varieties of mushrooms are obtainable, the former possessing the better flavour. A parasitic fungus sometimes attacks the cultivated variety. This causes rapid decay of the tissues with the emission of a strong odour, while the stem may be considerably enlarged.

Canned Vegetables

As a means of preservation, large quantities of vegetables are canned. The methods of canning employed will receive more detailed consideration in a subsequent chapter. All vegetables, particularly peas and beans, should be graded according to size before they are treated in this way so that the contents of each can will be as uniform as possible. Not only is the appearance improved by this practice ; it facilitates processing and sterilisation. Thus in the case of peas the heat required to process large peas would overcook the smaller ones and impair their nutritive value. Copper sulphate was formerly added to peas in cans to preserve their colour, which often changed to greyish-yellow and spoiled their appearance. Copper is now forbidden for this purpose, as it is one of the metallic colouring matters which may not be added to any food to which no preservative has been added. The colour of the vegetables is now retained by virtue of the improved methods of processing employed.

Composition

The average chemical composition of many vegetable foods in their raw state has already been considered. General consideration is now given to the changes which may occur when vegetables are cooked. As with fruit, vegetables are notable for their high moisture content. Their composition includes fibrous matter and carbohydrate, mineral matter, vitamins and organic acids together with relatively small quantities of protein and fat. This composition is never constant, even in the same class of vegetable, owing to the effects of such variable factors as soil, climate and rainfall. Apart from the food value of their separate constituents, vegetables are often valuable because of their palatability and flavour, both of which produce an appeal to the palate and assist in digestibility and assimilation. Their *mineral content* is important. The minerals are present in the form of organic salts which assist in neutralising the acid residues of other foods. The mineral salts present are usually calcium, phosphorus, iodine, copper, iron and manganese. The calcium content is well utilised in human nutrition, while the iron, which varies considerably in different types of vegetables, is generally greater in proportion in green vegetables, being associated with the chlorophyll content. All vegetables contain a certain percentage of indigestible *fibre*, which exerts a laxative effect although it is not assimilable. This fibre is important in that it provides roughage. Its action is mild and non-irritant. The *vitamin content* is also important. Vitamin A is usually present in all green vegetables in fair proportions, together with vitamins B_1, C and G to a lesser degree. Vitamin D is found along with vitamin E, but in insignificant amounts. The final vitamin content is, however, dependent upon the methods of preparation and cooking. Vitamin A, together with carotene, is not lost in the cooking water to any great extent.

While it will probably be destroyed by oxidation, ordinary methods of cooking appear to exert little effect. Vitamin B_1 is resistant to heat in an acid environment ; normally, little is lost in cooking. As this vitamin is soluble in water, however, losses are significant if the cooking liquor is decanted. This is also the case with vitamin B_2 (G), which is soluble in the cooking water. Vitamin C is readily oxidised, while there is a slow loss of ascorbic acid in cooked vegetables owing to oxidation taking place between cooking and consumption, particularly if the interval is lengthy. Dried vegetables such as peas, beans and soya beans contain concentrated supplies of carbohydrates, fats and proteins owing to the fact that they have lost much of their moisture content.

Nutritive Value

The nutritive value of vegetables is important, as these articles are classed as protective foods, furnishing many substances necessary for adequate human nutrition. The average diet consists largely of protein substances such as meat and fish together with starchy foods which are devoid of certain essential vitamins and minerals, which can only be supplied by an intake of suitable vegetables. The final nutritive value of vegetables, except in the case of vegetables eaten raw in salads, depends upon the method of cooking employed. However this is carried out, some losses are likely to ensue since various amounts of mineral matter are lost in the liquid in which they are cooked. This is also the case with fruit, but it must be remembered that fruit juices are invariably consumed whereas vegetable liquor is usually discarded. Boiling in water, the normal method of cooking, causes the greatest loss of mineral matter, between 30 and 40 per cent. occurring when this method is used. It has been reported that 40 per cent. of the manganese content is lost when vegetables are boiled in water, together with some 30 per cent. of the mineral salts originally present. When vegetables are steamed or cooked under pressure, the over-all loss of minerals is reduced to between 15 and 30 per cent. The losses may be increased according to the time the vegetables are boiled although, in the case of potatoes, excessive losses are prevented if these are cooked in their skins. No loss occurs when potatoes are exposed to the atmosphere during cooking or fried in fat, except as regards their moisture content. When considering the nutritive value of vegetables it is important to bear in mind that their dietary qualities are of little significance unless the retention of the protective elements can be guaranteed. For this reason great care in cooking is essential to ensure the important food constituents are preserved as fully as is possible. This is recognised by nutritionists, who now state that rapid cooking of vegetables in the absence of air in pressure cookers will allow maximum retention of the important nutritive constituents.

Epidemiology

Very few infectious disease outbreaks have been traced to the consumption of fresh vegetables. The fertilisation of vegetables with human excreta —a practice frequently found, particularly with vegetables grown on sewage farms—is one which should be discouraged, since it predisposes both the vegetables and the consumer to infection by pathogenic diseases, particularly if the produce is eaten raw as a constituent of salads. Infection may also be carried by vegetables exposed for sale, by street dust, prowling animals, insects and by the handling they receive during sale. Great care should be exercised to ensure that lettuces, radishes, watercress, celery and other vegetables normally eaten in a raw condition should not be exposed to any form of contamination. Instances have been reported in which cases of *typhoid fever* have occurred following the consumption of infected vegetables. Outbreaks have also been traced to the consumption of infected watercress, grown in infected beds or washed with water containing *Salmonella typhosus*. One outbreak in this country, which involved 118 cases, was traced to watercress grown in beds fed with sewage-contaminated water. Another outbreak, affecting 18 persons in America, was traced to the consumption of infected watercress sandwiches. Watercress still grows in polluted streams even in this country, and may find its way into the public market unknown to the authorities, constituting a hazard to public health. Rhubarb grown on soil manured with infected excreta has also produced cases of typhoid fever. In the United States of America celery caused forty-nine cases of typhoid fever in an institution where sewage had been used for manuring celery beds. It is also reported that *cholera* has been spread by the consumption of infected strawberries.

An outbreak of *food poisoning*, affecting seven individuals, was reported by Savage and White as being due to the consumption of tomatoes infected with *Salmonella typhi-murium*. MacEwen reports a case in which a young girl contracted hydatid cysts as a result of consuming lettuces contaminated with the eggs of *Tænia echinococcus* and stresses the fact that dogs, which harbour this parasite, should not be allowed to enter vegetable gardens or to come into contact with vegetables. Bruised vegetables provide a ready means of entrance for parasitic organisms through the injured portions, while a careful examination of vegetables in shops and markets would no doubt disclose considerable bacterial, and particularly coliform, pollution. In cases of disease outbreaks it is difficult to trace any infection to vegetables, although these may be the source of the trouble. Vegetables pass through so many hands that it is impossible to prove cause, particularly as many days may have elapsed between harvesting, sale and consumption. Maggots and larvæ of various kinds are often found in vegetables. The consumption of food infested in this way may result in gastro-intestinal disturbances. Tomatoes are particularly subject to attacks of this description. Their use in soups and sauces, for which they are pulped, may cause the source of infection to be broken up and distributed unnoticed throughout the pulp.

The consumption of green potatoes may cause a form of poisoning due to glucoside solanin, which may accumulate in the green parts. Early potatoes may have a high solanin content ; sprouted or diseased potatoes may also show an excessive percentage of this substance. Cooking in the normal manner does not destroy solanin. Several outbreaks of disease due to the consumption of green potatoes have been reported. In spite of the known toxicity of solanin, some authorities, however, feel that the cause of infection was *B. proteus*, which grows well on potato medium. Rhubarb leaves are especially poisonous owing to their high oxalic acid content. The use of insecticides on vegetables is essential, and sprays containing both arsenic and lead are used for this purpose. Many of these liquids possess an oily base. This renders their removal difficult even when the vegetables are thoroughly washed. Regulations regarding the use of spraying substances have been promulgated in many countries. Similar action is required in this country, since many untraced illnesses may be due to the use of these substances. It is extremely important that vegetables should be produced, handled and sold under the same hygienic conditions which apply to other foodstuffs. When present methods of handling and distribution are considered, it is obvious that this point is not receiving the attention it deserves. While the addition of copper salts to vegetables is prohibited in this country, canned vegetables imported from abroad have been found to contain large percentages of such salts. These substances have also been found in imported tomato pulp. It has not been proved that copper, which is retained in the system, is invariably harmful, but in view of the probabilities the point deserves serious consideration. An outbreak of food poisoning due to peas cooked in a copper vessel and retaining a large proportion of this metal in their substance has been reported. During 1944 forty-two cases, all men, were reported as a result of this practice. Many cases of poisoning due to the consumption of fungi resembling mushrooms have been notified. It is probably fortunate that, of the various edible fungi which grow in this country, comparatively few are poisonous. It should, however, be remembered that there is no simple test which enables edible and non-edible types to be distinguished.

Control

The inspection of vegetables is mainly directed towards their visible condition, together with the presence of insect pests and harmful chemicals. Any vegetables showing incipient decay, disease or infestation should be condemned forthwith. The conditions under which they are sold should also be investigated. Insanitary handling and contamination by dust and dirt, particularly on hawkers' barrows, carts or open market stalls, should not be overlooked. In the past, the fact that vegetables were either washed when consumed in a raw condition or boiled before being eaten has sometimes tended to affect the attitude of the inspector. When it is remembered, however, that many cases and outbreaks of poisoning occur annually, the origins of which are never traced, the part which vegetables may play in such causation deserves attention. It is not too difficult to believe that the proper hygienic handling of vegetables and their thorough inspection might eventually result in a diminution of food poisoning cases, especially of the milder type.

CHAPTER XXIV

FOOD PRESERVATION (1)

From the earliest times man has sought to preserve food caught or grown in times of plenty so that he might be enabled to maintain his family and himself when shortages made themselves apparent. His first attempts at preservation were to keep surpluses in caves or pits—in fact, in any place which was sufficiently cool to maintain the food in an eatable condition. The discovery that salt exerted a preservative action followed, and food was salted in order to preserve it. Man progressed still further and found that the application of smoke would preserve food, particularly meat and fish ; the action of the sun was also used to dry substances which would otherwise have decomposed and become useless. While successful on a small scale, these efforts would be of little assistance in preserving the enormous quantities of food now consumed after subjection to the various preserving processes available. Storing in cool caves has given way to modern methods of refrigeration ; salting and smoking are still employed for food preservation, but have been largely superseded by modern methods of quick freezing and canning, while primitive attempts at dehydration by the drying action of the sun and wind have developed into modern large-scale processes. The food preservation industry also enjoys the advantage of additional methods which make use of the preservative action of sugar and fermentation.

The food-preserving industry—and it is an industry in itself—has wide ramifications and has developed into a very large business. Without the scientific efforts employed it would be quite true to say that large quantities of food now annually produced would be wasted and a great number of the world's population faced with starvation. Indeed, the present population could not be supported unless large quantities of food could be preserved for future use. As the various methods of treating food in this manner have been discovered, so has the population of the world increased. The growth in population has been at least partly due to the increase in available foodstuffs which, in turn, had been made available by the discovery, application and improvement of methods of food preservation.

Refrigeration

As already mentioned, the value of low temperatures in the preservation of food has been appreciated by man from the earliest times. Indeed, the use of caves and cool water supplies—particularly the latter method—are still employed in many parts of the world. In many districts milk is still stored in containers which are allowed to stand in cold water or in running streams while awaiting collection. Subsequently the use of ice for food preservation became common. Ice was employed even in the Roman era for the preservation of food transported over long distances, and continued to be used for many years until methods of mechanical refrigeration were invented. The first compression refrigerating apparatus was produced in 1834, while the first cold-storage warehouse came into use, in America, in 1865. Since that time there has been a steady expansion in the provision of cold-storage accommodation in all countries, not only for the storage of food but also for the production of ice for use by the distributive trades, the fishing industry and for home use. The invention of the comparatively small automatic refrigerator has now largely superseded the use of ice in the home and in retail shop premises. The modern development of refrigeration has been of great value to the food trades, and particularly to agriculture, both of which have rapidly expanded as a result. Tropical and sub-tropical countries have benefited to a considerable extent by the introduction of modern cold-storage methods, while the meat industry could not exist at the present time without its assistance.

Refrigeration methods may be classified into three groups. The first is known as *chilled storage*. In this method temperatures of between 32° F. and 45° F. are employed for the preservation of articles such as eggs and milk. Chilling is also employed for foods which are to be used within a short time after production. The second group covers *cold storage* in its normal sense, using temperatures between 0° F. and 32° F. for the preservation of meat, fish, butter and other foods not affected by freezing-point temperatures or temperatures below this point. In the third group, which is a modern application of refrigeration and is known as *quick or deep freezing*, temperatures below 0° F. are used for the rapid treatment of a variety of foods. The employment of this method has appreciably increased during recent years. Quick freezing is used to preserve a variety of foods which might otherwise be denatured or lose some of their nutritive values by ordinary freezing methods. Cold storage and deep freezing are employed for foods which have to be kept for lengthy periods.

The main reason for the storage of food at low temperatures is to prevent spoilage or decomposition caused by (*a*) the activities of micro-organisms initially present in the food, and (*b*) autolytic changes produced by enzymes or chemical agencies normally found in foods of plant or animal origin. Both these types of change may be retarded at low temperatures, which reduce the speed at which bacterial growth occurs and prevent chemical or enzymic action. The reduction in bacterial growth is important. Under normal conditions of temperature an initially low number of bacteria will multiply into millions within a few hours, altering the quality, chemical composition, taste and flavour of the food which they attack. All bacteria do not develop well at one particular temperature or range of temperatures. Some require high temperatures for their rapid growth ; others develop most rapidly when conditions are cool. The greatest number, however—and these include the bacteria most likely to cause food deterioration—prefer temperatures in the middle ranges of the scale. The activities of these organisms are considerably restricted by cold storage. Organisms must also obtain sufficient food for their growth, while moisture must also be available if they are to take advantage of the available food. The process of refrigeration restricts the moisture supply and so prevents organisms making use of the available food. The organisms then lie dormant until temperatures once again rise. Many vegetable and fruit products respire for a considerable time after they have been harvested. This process assists in the development of a suitable ripeness for consumption. The use of cold storage, therefore, is of further value in controlling development, so that the fruits and vegetables concerned reach a suitable state of maturity at the desired time. This is particularly important in the case of fresh fruit, which, having in many cases to travel long distances, would be over-ripe when it reached the consumer if not cold stored.

The *public health value* of cold storage cannot be over-estimated, particularly as regards prevention from deterioration and the preservation of nutritive foods for future use. The incidence and transmission of many diseases, particularly food poisoning, have been greatly reduced by the use of refrigeration. Its more widespread application would no doubt bring about a still greater reduction. The *economic value* of refrigeration is even more obvious. The bulk of some foods is produced during certain seasons of the year, particularly meat, eggs, bacon, fruit and fish. If supplies were allowed to reach the markets during these peak periods the glut would result in low prices and, for a time, too much of everything. Out of season, however, these articles would be scarce, so that prices would rise. Apart from prolonging the life of the product, refrigeration helps in maintaining an even supply of desirable foods throughout the year. It also enables food produced at any period to be sold when the demand is greatest. Food from cold stores can therefore be sold in prime condition at a higher price than would be the case at the time of production, yet lower in cost than would be possible in times of scarcity.

At one time the use of cold-storage methods for the preservation of food was viewed with suspicion. As an instance, chilled or frozen meat was thought to be the prerogative of the poor. Yet these same critics of the process have had good reason to be thankful for the invention of refrigeration, without which they would have had little or no meat at all during and after the War years. It must be granted, however, that cold-storage premises were not always operated or supervised as they are to-day. This, no doubt, had much to do with the fears expressed in connection with food preservation by refrigeration. The greater supervision of cold storage and the desire of the operators to deliver quality products, together with improvements in refrigeration technique, have resolved many of the early prejudices against this method. Indeed, the fact that meat has been cold stored is now seldom obvious to the majority of consumers. Many foods which have been refrigerated are of better quality than fresh foods which have been carelessly handled or stored. Suitable conditions of refrigeration do not produce those alterations in flavour and taste which result from many other food-preservation methods, such as salting, smoking or dehydration. Not all foods can be stored at the same temperature for the same length of time if they are to remain in prime condition. Chilled storage is generally employed for food which is to be consumed within a short space of time after production. If the food has to be kept for long periods, it is frozen or maintained at very low temperatures. Refrigeration of food is now a highly technical science, since the character of the food, its cellular structure and chemical composition must all be taken into consideration when refrigeration temperatures are being determined. The employment of a different temperature for each separate food would involve prohibitive cost. It is therefore usual, in the absence of an optimum temperature for all types, to provide temperatures suitable for certain groups of foods.

Constant temperatures during storage are important, this being particularly so in the case of fruit and vegetables subjected to cold-storage treatment. Variations may cause serious losses if the products become frozen. On the other hand, a rise in temperature is likely to shorten the storage life of certain foodstuffs. Heat is evolved by vegetables and fruit together with carbon dioxide gas. Due allowance must be made to cover this, as the amount of heat may vary considerably. Pears, peaches, cherries and lettuces have high respiration rates and produce more heat than do apples, potatoes and onions. This factor must also be borne in mind during transport in cold storage. Generally speaking, low temperatures are essential for the proper preservation of meat, fish, dairy products, fruit and vegetables. *Humidity* in the cold store possesses both economical and practical significance. During refrigeration the moisture content of goods so treated is likely to be reduced by evaporation unless sufficient humidity is maintained. Loss of moisture means loss of weight. This causes direct loss to the owners of the goods. In addition, articles which lose their moisture content shrink and become dry. Each food requires its own optimum conditions of humidity during storage. In general, the higher the moisture content of the food the greater the degree of humidity which must be maintained. For this reason meat, fruit and vegetables require a relative humidity of 85 to 95 per cent., eggs 85 per cent., while dried fruit, usually stored at chilling temperatures, requires only some 60 per cent. humidity. Excessive humidity, however, will encourage the development of bacteria and moulds, particularly in the case of meat, eggs, fruits and vegetables, so that it is necessary to strike a balance in order that deterioration is reduced to as low a level as possible. Temperature also exerts an effect in this direction. With low temperatures, shrinkage is likely to be greater. Practically, it is impossible to control humidity in the case of all types of food, but efforts are usually made to provide separate storage rooms with high humidity for vegetables, those articles which possess a high moisture content and eggs, during the storage of which humidity is important. Variations in humidity during storage will cause the articles to sweat, moisture being deposited on their external surfaces. This is likely to induce mould growth and to accelerate decay due to bacterial activity. The same effect may be produced when articles are removed from cold storage.

The *ventilation* or *air movement* of cold-storage rooms must be carefully considered, as many articles, especially fruit and vegetables, respire and emit carbon dioxide gas, which if allowed to increase to any considerable extent may cause undesirable changes in their substance. Air movement is, therefore, necessary to prevent concentration of this gas. In spite of this known fact, many cold-storage engineers state that no air movement is necessary ; others consider that the air should move at a high velocity. No optimum conditions have yet been agreed, many varying applications being used. To assist in the proper movement of air, goods should be placed or stacked in rooms so that air is able to circulate freely round and between them. Temperatures should be frequently checked to guard against serious fluctuations, while humidity should be carefully watched. If air entering the cold store is already moisture laden, it may be dried by means of calcium chloride before being distributed. Alternatively, moisture can be added if desired, but no automatic humidity control, as is the case with temperature, seems to have been practised. In rooms where certain foods, such as eggs, are stored ozone has been used to check the development of bacterial life under increased humidity. This gas cannot be used with fatty foods as chemical changes of an oxidative character, which cause rancidity or off-flavours, are accelerated. Eggs, being protected by their shells, can be treated successfully, but only a few parts per million of gas should be introduced into the air entering the rooms at periodic intervals. This treatment is stated to reduce attacks by moulds. It will also permit the use of higher humidities than was formerly possible. Carbon dioxide has also been used for this purpose, particularly in connection with the storage of eggs, fruit and meat.

In view of the short distances over which food is carried in this country, little use is made of *refrigerated transport*, insulated vehicles and containers being employed to maintain goods at low temperatures during their carriage from the port of entry to the cold stores or distributive premises. Cold storage on shipboard can be handled in the normal way, but in those producing countries where foods have to be transported at low temperatures for long distances, either to the point of consumption or to ports for shipment, many problems have to be faced. The overriding consideration is the dead weight of the refrigerating unit or apparatus, which must be kept as low as possible. *Refrigerated rail vans* are one of the methods employed. They are well insulated with double walls and are frequently painted in a light colour to minimise heat absorption. Ice bunkers are provided at each end. These must be filled every twenty-four hours, depending upon the type of food carried and the weather conditions. In some cases a forced-ventilation system carries air through the ice to pre-cool the contents. Normally, however, the goods are pre-cooled before being loaded, as the vans are mainly designed to retain goods at low temperatures and not to act as refrigerators.

The manner in which goods are packed is also important. To ensure free circulation, the air passes through ice at floor level, through the goods, then back through the ice to be once more cooled, the design of the vans ensuring that the air circulates in the required manner. The ice is mixed with salt. If the separate pieces are too large, excessive spaces will occur ; if they are too small, they tend to pack too closely together. By the efficient use of ice and salt, temperatures well below freezing point are maintained in these vehicles. By suitable arrangement and by providing a prepared location for each food in relation to the refrigerant, it has been found possible to carry foods requiring slightly different storage temperatures in the same van. Vans provided with *ammonia refrigeration* are also used, the gas being compressed by means of power furnished from the axle when the van is in motion. An electric motor provides power to operate the compressor when the vehicle is stationary. This is seldom required as the brine tanks provide suitable refrigeration for short periods. Expansion coils are in contact with the brine, while an air-cooled condenser is fitted in the roof of the van, thermostatic control being provided to regulate the temperature. By this means excessive moisture, produced when the ice melts, is avoided, and no delay is required for the further addition of ice and salt during the journey. *Tank wagons* are used for transport of milk both in this country and abroad. These are not refrigerated, but between the glass-enamelled or stainless steel lining and the external covering suitable insulation is provided. This maintains milk or other liquids, pre-cooled to low temperatures, in a cold condition. During lengthy journeys a temperature rise of 3° F. is uncommon. *Solid carbon dioxide* or *dry ice* is a popular refrigerant during transportation and can be used in rail vans and road vehicles. Its most frequent application in this country is for the transportation of ice-cream in box-like containers, or in the delivery tricycles so familiar on city streets. Temperatures of —20° F. can be maintained. Solid carbon dioxide is well adapted for the transport of frozen foods, which require storage at low temperatures until consumed. The cost of carbon dioxide is at present reasonably high, but increased use should bring about a reduction in price. *Silica-gel refrigeration* is a comparatively new development. This material is produced by treating sodium silicate, which readily absorbs certain gases and moisture, with acid. The refrigerant is sulphur dioxide, which is allowed to expand in pipes which run the length of the refrigerated van. The gas is condensed by air-cooled condensers situated near the roof but protected from the sun. Two absorbers, which contain silica-gel, are provided, one fitted at each end of the van. These containers are insulated in fireproof compartments. Gas burners supplied from tanks fitted beneath the van furnish heat, which expels the gas from the silica-gel. Only one absorber is in use at one time, the other being allowed to rest so that the power of absorption is restored to the chemical. Constant temperatures can be maintained by this method. *Refrigerated road vehicles* are not common in this country, where insulation is satisfactory for the short journeys involved. Many such vehicles are in use abroad. Solid carbon dioxide is mainly employed in these vehicles for refrigeration purposes, the weight of the normal refrigeration apparatus being prohibitive, while the employment of ice and salt would cause the production of moisture which would, in turn, rot the woodwork and produce corrosion. Thermostatic control is sometimes provided to the air circulation, but usually the refrigerant is stored in a separate bunker from which it volatilises through the food compartment. For small containers, used in the transport of ice-cream or dairy products, *frozen brine cartridges* are often used to maintain temperatures between −10° F. and −45° F. These are effective up to twenty-four hours after insertion.

There are three standard *systems of refrigeration* in use. The *compression system* is commonly employed, a compressor removing gas from an evaporator, compressing it and delivering it to a condenser, where the compressed gas is cooled by air or by running water. The cool gas passes to an evaporator, where it expands under reduced pressure to absorb heat from its surroundings. This cycle is continuously repeated. In the *absorption system* the pressure and temperature between the evaporator and the condenser are increased by the application of heat. A compressor is not employed, the alternate use of heat and cold in a closed pressure tank being substituted. The *air system* permits air to be compressed and passed through coils, where it is cooled by means of cold water. The cold compressed air operates an air engine, expands and becomes very cold. The refrigerated air is piped off to the cold room. *Vacuum refrigeration* is a method comparatively new to this country and is entirely different in operation from the usually accepted methods. The operation of the plant depends upon the principle of lowering the absolute pressure in an evaporator until it is at the pressure equivalent to the required temperature. A number of *refrigerants* are commonly employed, the chief of these being ammonia, freon, sulphur dioxide, methyl chloride and carbon dioxide. Ammonia is commonly employed in large plants ; the other gases are often used for domestic refrigeration.

A number of *methods of freezing* are at present employed. In all of them the purpose is to maintain a particular food at a temperature sufficiently low so that bacterial activity is reduced to a minimum and to prevent, as far as is possible, autolytic activity of the enzymes. The actual method used with a particular type of food depends upon its biological character, the length of time preservation has to last, the actual method under which the food is obtained and the type of refrigeration available. During the past twenty years there has been a marked increase in the types and quantities of food preserved by refrigeration. The circulation of air, normally used in cold stores, has now to face competition from other methods, such as direct contact with cold brine, either by direct immersion or a refrigerated brine spray, or indirect contact with the refrigerant. These latter are known as *quick-freezing methods*. Certain foods, suc has fish, which have powerful enzymic systems cannot be preserved at chilling temperatures (40° F. to 45° F.) but must be frozen at temperatures of 0° F. or below. Meat, poultry, fruit and vegetables are also successfully preserved in this way. Slow freezing causes ice crystals to form throughout the substance, particularly between the temperatures of 31° F. and 25° F. Rupture of the cells contained in the substance occurs when large crystals are formed, particularly in vegetables, owing to lack of elasticity in their cells. Slow freezing also causes loss of liquid, which drips away when the goods are restored to normal temperatures. This is minimised by means of quick-freezing methods. In the normal cold room periods up to seventy-two hours are required to freeze the food stored therein. The use of very low temperatures, with the rapid circulation of cold air, enables the product to be more quickly frozen, the actual time depending upon the bulk of the product being treated. For this reason modern methods of quick freezing have been devised and are now being more widely employed.

Quick freezing of food is a comparatively modern process which largely owes its present development to Clarence Birdseye, although attempts to freeze fish and store them date back to 1841. Temperatures of 0° F. and below are employed. The advantages claimed for the process are that less time is required for freezing, there is less leakage when defrosted, the original article is not in the majority of cases greatly altered in appearance, while the articles frozen are easily handled. The use of low temperatures enables the rapid transfer of heat by conduction rather than by convection, as employed in the older refrigeration methods. What is termed " maximum crystal formation " quickly occurs, smaller ice crystals developing owing to the rapidity with which the various articles are frozen. This is one of the main advantages, since in the majority of cases of frozen foods, particularly fruit and vegetables composed of cellular matter, the cell walls are not ruptured as would probably be the case with normal freezing methods. Changes in the protein content are also less serious.

With this process the cell walls are seldom damaged, although immunity depends appreciably upon their physical and chemical structure. Spinach is affected, but rupture of the cell walls accelerates the cooking time ; strawberries are also affected, although the fact that the juice can escape when defrosting takes place is not a disadvantage. Raspberries can be quick frozen without any deterioration in quality. It should be noted that quick freezing does not conserve the entire juices, the loss increasing when the food is thawed according to the length of time during which the article has been frozen. Some autolytic action takes place in the food when stored under these conditions, whilst enzymic action is slowed down. The final quality of the article treated depends upon the method of freezing, the preliminary treatment, the type and quality of the packing materials, the storage of the frozen product, its length of storage and the care exercised in handling. Very low temperatures must be used if marked changes following a few weeks' storage are to be avoided. Fish was the first article to be subjected to the quick-freezing process. Now very many different types of food, such as vegetables, fruit, sausages, poultry, fruit juices, cream and ice-cream are treated in this way.

With regard to vegetables, every type cannot be treated successfully. With some varieties there are changes in colour, taste and texture. In the case of vegetable foods a preliminary blanching or cooking in boiling water is given, until the temperature throughout the product is approximately 182° F. Lower temperatures for longer periods are also used, while the use of dry steam for blanching is said to yield a better product with less nutritive loss. In spite of certain defects, quick freezing is an excellent method of food preservation, as the quality and flavour are well retained in most articles, while, provided the goods are properly stored, long periods of storage do not alter the keeping quality. The foods are packed and are frozen in the package, cellophane wrappings or transparent or vegetable parchment papers being usually employed. The freezing of pre-packed foods saves space, which in turn saves storage and transportation costs, while wrapping costs on retail sale to the customer are avoided as the food is already wrapped. This method provides for the production of a uniform article, attractively and compactly packed and sealed against contact with air, thus preventing contamination, while reducing losses of moisture and the risk of oxidative changes.

While considerable success has been achieved with quick-freezing methods, further experiment and research is still necessary to determine the optimum methods of treatment, storage, pre-treatment and handling. Methods of cooking quick-frozen foods are also being investigated to ensure that the product reaches the table in the best condition. Various types of containers are used for frozen foods apart from the wrapping materials already mentioned. Cardboard cartons lined with various types of wrapping paper, metal containers and treated paper tubs and cups are employed, packing sometimes taking place under vacuum. When thawed out, quick-frozen foods deteriorate more rapidly than do fresh foods. When frozen, foods are subject to dehydration, particularly if unwrapped. Those containing fat or oil may also be subject to oxidation. This defect is reduced by the use of airtight packages, which prevent contact with oxygen. The food is often coated with a thin film of ice-glaze or oil, or is packed in moisture-proof wrappings. Salt and sugar are used in certain cases to improve the colour, flavour and texture of various foods, while vacuum-sealed containers have also been employed to reduce the risk of discoloration. In spite of these precautions, food often darkens when defrosted.

Frosted foods are transported in bulk in strawboard containers, several layers of insulating paper being provided. They require special insulated containers, together with refrigeration, during their journey from the factory to the distributor's premises. While some foods, such as poultry, may be defrosted by the dealer before sale, their wholesomeness is improved if they are sold in a frozen condition. Frozen foods can be cooked directly without defrosting. This method will lessen the chance of deterioration. Only the highest-quality food should be quick frozen, since foods, with the possible exception of flesh foods, which become more tender, are not improved by the process, while poor foods remain poor. The bacterial content may be reduced to some extent by storage at the very low temperatures employed. Some organisms survive, as do certain types of moulds, but yeasts are more susceptible. Bacterial action quickly develops with any rise in temperature. There is also evidence to show that the vitamin content is conserved to a greater extent in foods treated in this way than is the case with unrefrigerated foods. Quick freezing is now an important industry, whose growth has been rapid since the termination of the War. The present price of many frozen foods is likely to be reduced as the result of further development of the industry.

The *nutritive value* of foods subjected to refrigeration is not substantially altered, except possibly as regards certain vitamins. It has been authoritatively stated that the vitamin content is more completely safeguarded in refrigerated than in unrefrigerated foods. The structure of the product and its composition remain unaltered, as cold storage at temperatures just above freezing point merely prevents biological alterations in the food and its subsequent decomposition. The method of storage is, however, important, as foods may absorb unwanted flavours from other articles stored nearby. A slight loss of moisture also occurs. This is again dependent upon the method of treatment. If excessive moisture is allowed to drain from improperly frozen articles some loss of nutritive value will follow. Vitamin C is affected to some extent by the retardation of enzymic action, while fats may oxidise and become rancid. The skins of certain articles may darken in colour. Improved techniques of refrigeration have overcome many of these difficulties. Frozen or chilled food is virtually as palatable, attractive and nutritious as the fresh variety. When the quick-freezing process is employed, the blanching of vegetables produces more loss of soluble constituents into the boiling water, this loss varying according to the time during which the process is continued. Less loss in this connection ensues when steam is employed for this purpose. Refrigeration does not affect the vitamin A, D or G contents, while as much vitamin C may be present as in the fresh product, dependent upon the method of treatment prior to storage at reduced temperatures. In most fruits and vegetables the vitamin C content is unimpaired providing handling has been satisfactory.

The absence of any *epidemiology* in connection with refrigerated foods is a testimonial to their safety. There is no record of food poisoning outbreaks or other infectious diseases having occurred in connection with such foods, with the exception of ice-cream. Pathogenic organisms cannot develop under refrigerated conditions, while most consumers are aware of the dangers of decomposition and spoilage once food has been thawed or defrosted. Generally, the rate of spoilage of food which has been stored at low temperatures may be much greater than that which has been retained under chilled conditions. At temperatures below 0° F. bacterial decomposition ceases entirely, while enzymic changes are considerably reduced. Large numbers of micro-organisms die under severe refrigerated conditions, although certain varieties may survive and even multiply at low temperatures. The withdrawal of food from refrigerated conditions encourages a recrudescence of bacterial growth, the organisms obtaining their nutriment from the juices in the food. Damage to the tissues and rupturing of the cells due to mishandling prior to storage, or to severe refrigeration conditions, provides the organisms with adequate nutriment and may allow them to penetrate the substance of the food. It must be remembered that certain organisms will remain unimpaired during refrigeration. The spores of *Cl. botulinum* have been proved to be unaffected by the period, temperature and method of freezing, while toxins may exist in frozen food for some time. There appears to be little danger of botulism from frozen foods, always provided they are not defrosted and not allowed to stand for any lengthy period at room temperature. Members of the Salmonella group will, under certain conditions, grow on foods at low temperatures, but foods must be heavily infected before they can become dangerous.

The *control* of cold-storage methods is important, as frozen foods are not, in many instances, given any subsequent treatment. Hygienic plant operation and handling, together with an extremely pure water supply, assume great importance if the treated food is not to become infected with pathogenic bacteria which may develop later under normal conditions of temperature. The controlling official should inspect all cold stores regularly to see that they are maintained in a clean condition, that no offensive odours which might affect the food are present and that no rubbish or offensive matters are allowed to accumulate. Cold-storage rooms should be cleaned at regular intervals, while each year their internal surfaces should be disinfected and painted. The methods of preparation and handling should be supervised. All foods should be proved sound, free from odour, dirt and foreign materials before they are refrigerated. The rapid increase in the number of cold-storage cabinets and quick-freeze containers in retail shops renders it imperative that they should be frequently inspected for cleanliness. It should be a strict rule that the refrigeration space available is sufficient to prevent defrosting of any food. No article which has once been thawed should be re-frozen.

Dehydration

The drying of food for future use is of very ancient origin. Foodstuffs were first dried by natural methods to ensure lengthy keeping, the action of the sun and wind ripening and drying grain, nuts and the seeds of innumerable plants. Having provided himself with shelter and clothing, man realised that food could be preserved in times of plenty by this method and adopted drying by natural methods as a means of retaining food until it was plentiful once again. While sun and wind were the original drying agents, smoking was also developed for this purpose, especially in the case of meat and fish ; further the drying action of salt also came to be understood, particularly in connection with fish. Salt itself was produced by the drying action of the sun on sea-water. Fruits were also sun dried. The method of drying varied according to the climate. In tropical and subtropical countries use was mainly made of the sun's rays ; in more temperate zones smoking and salting were more commonly employed.

The first person to carry out the drying of food in a more or less scientific manner was Graefer, who, in comparatively recent times, treated vegetables with hot water for a short period and then dried them, similar methods being used by Dize in the case of meat. In 1795, Eison, in Central Europe, used heated air, a room being set apart for this purpose in which a stove and drying racks were provided. The Frenchmen, Masson and Challet were, in effect, the inventors of the modern system of dehydration. Masson used low temperatures to dry vegetables which had been cut into thin slices ; Challet co-operated with him to devise a system wherein drying was carried out in a current of warm air, the dried materials being hydraulically compressed. It was found that this method facilitated storage, handling and transport ; preservation for long periods was possible, while the flavour was not affected. Potatoes were one of the first vegetables to be dried, being treated in this manner in Australia more than fifty years ago. Dried potatoes were also produced shortly afterwards in the United States of America and in Germany. Appert, the originator of canning, is said to have dried milk many years ago, but dried milk owes its origin to the consumption of malted milk. Indeed, it is only during the last thirty to forty years that preservation by this means has achieved any great popularity. Even now the quantity of dried skimmed milk dwarfs the production of other types of dried milk.

Foods are preserved by dehydration, either by natural or artificial means, as their normal moisture content is greatly reduced. Various types of micro-organisms, such as bacteria, yeasts and moulds, together with numerous enzymes, cause food to deteriorate and decompose much more readily when moisture is available. Even with a low moisture content enzymatic changes may occur, but the probability of such action is greatly reduced. Spoilage, however, will occur when higher moisture conditions are re-established. For this reason suitable storage conditions for dehydrated foods assume great importance. *Atmospheric drying* cannot be relied upon to prevent fluctuations in the moisture content. While fruits are often dried by the action of the sun and wind, this operation is usually supplemented by artificial or mechanical means. Sun-dried products are spread in even layers on shallow trays placed upon the ground and exposed to the direct action of sunshine. Several days are required to complete the process, during which time the foodstuff may be contaminated by dust and other foreign matters. The food is also open to infestation by insect life, unless it has been previously treated with sulphur, while it is usually protected by suitable covers during short rain showers. After a period of exposure, the drying process is often completed by natural air circulation under cover.

Dehydrated food is the name applied to food which has been artificially dried. All vegetables are processed in this manner. The term *evaporated food* is sometimes employed to denote foodstuffs which are dried by natural means under controlled conditions. Foods are dehydrated by means of forced currents of warm air and are evaporated by the use of controlled warm-air movements under natural conditions without any mechanical means being employed. As the dehydration process became more readily understood and developed the number of foods treated in this way rapidly increased. The main foods which are subjected to dehydration are meat, fish, fruits such as raisins, currants, sultanas, apricots, peaches and plums (which form prunes), vegetables such as potatoes, carrots and spinach, full-cream and skimmed milk, fruit juices and eggs, either separately as whites and yolks or combined. Meat has been dehydrated for restaurant use ; fish is commonly treated by this same process.

Drying is one of the simplest, cheapest and most effective methods of preserving foodstuffs, so that the dehydration process possesses many *advantages*. As is the case with the canning of food, dehydration enables food to be dried when cheap and plentiful, so that it may be disposed of when supplies of a particular food have decreased and the demand is therefore likely to be greater. Food which would otherwise spoil can be preserved for future use, thus extending the utilisation of many foods. In addition, foods of this description can be distributed to reach a greater number of consumers who might otherwise be deprived of their use. The weight of food to be packaged and transported from the centres of production to the consumer is reduced. This is particularly important when the food has to be shipped overseas. During the last War large quantities of dehydrated foods were imported into this country, with a considerable saving in shipping space. As a corollary, the use of dehydrated food in the rations supplied to troops serving overseas solved many transport difficulties. If the foodstuff is processed in an adequate manner and properly reconstituted, dehydrated food forms a very good substitute for fresh food, while the nutritional values are substantially retained. No sterilisation process is required, which saves the expense of the necessary plant, but, as with all foods, hygienic care of the raw materials and methods of treatment during production are of particular importance. As all the inedible portions are removed before the food is dried, every scrap can be utilised. A required quantity can be prepared for consumption without deterioration of the remainder. If packaged, the form of container required is cheaper to produce than is the metal can. From the public health point of view dehydrated foods bear comparison with any other type of preserved goods. Very few foods are prepared without certain *disadvantages* being apparent. Food treated by dehydration is no exception to this rule. The condition of the goods reaching the consumer may not be satisfactory due to damage in transit, mostly by reason of unsuitable containers. Excessive re-absorption of moisture may occur, followed by bacterial deterioration. This produces loss of quality and, finally, unfitness for use. Many foods which have been dehydrated quickly take up moisture during storage. This may be due either to the type of container used or to faulty storage conditions. The same principles apply to insect infestation. In the case of packaged dried foods, changes which have occurred may not be visible to the consumer until after purchase, as none of the obvious signs of unsoundness evidenced in the case of canned goods or in food preserved by other means may appear. Again, the time taken for the re-absorption of moisture prior to cooking may be quite a lengthy period. If this process is curtailed in any way the food can be most unpalatable. As a result the reputation of dehydration as a means of food preservation suffers, although in many cases the defects are due to lack of care during preparation for the table. In spite of the obvious advantages, the dehydration process is not extending so rapidly as other means of food preservation, particularly canning, probably due to the poor condition in which such products formerly reached the consumer and the unsatisfactory appearance when compared with foods preserved by other methods. In addition, such food must be prepared for consumption and cannot, as in the case of canned or frozen goods, be eaten immediately it is purchased. Where bulk has to be reduced, however, without loss of nutritive value, the process has been found of considerable value.

Various *methods* are employed for the removal of the moisture content from different kinds of food, the particular process depending substantially upon the type of food requiring treatment. In countries where weather conditions permit, exposure to the sun's rays is still employed for fruit drying. *Mechanical forms* of dehydration are now widely used, heat being supplied either by electricity, gas or oil. The apparatus employed varies from the small drying cabinet to plant which operates continuously and is capable of handling large quantities of foodstuffs. *Evaporators* or *kilns*, which depend for their efficiency upon the circulation of heated air by natural draught, are also widely employed. These evaporators may be several stories in height, the solid floors being replaced by metal or wooden gratings, upon which the material to be dried is placed. The air is heated by means of steam pipes or with gas- or oil-fired furnaces, which are generally situated below ground level. The heated air rises to pass through the material exposed in thin layers to its action. In its passage the heat removes the moisture. The material to be dried is first placed upon the topmost floor of the evaporator. It is then moved downwards from floor to floor as more and more moisture is driven off until it reaches the lowest floor. Here the low moisture content remaining in the foodstuff is exposed to the fiercest heat, so that the process is quickly completed. The thermal efficiency of the operation is not high. Normally the heated air is used once only. Temperatures must be carefully controlled so that the moisture content and the quality of the final product is uniform.

Forced-draught driers are also used. With this type of apparatus the heated air is generally re-circulated so that maximum heat is utilised and fuel economised. These driers are sometimes provided with separate compartments, each of which has an air inlet and outlet. *Tunnel driers* are also employed for dehydration purposes. This type of apparatus affords more accurate control of humidity, temperature and other essential conditions, while from the hygienic standpoint the method is more satisfactory than either sun drying or the methods of evaporation employed. A tunnel between 30 and 40 feet in length with a large sectional area is used. The material is placed upon shallow trays. These are stacked in carriers which travel through the tunnel. Hot air is supplied from large heating units, the heated air being injected into and through the driers by means of fans. Oil or steam heating may be employed, the latter being less economical. Care must always be taken to ensure that the fumes from the heating agent do not come into contact with the food being treated. As with evaporators, the highest temperatures are used to treat foodstuffs at the end of their passage through the tunnel, when the moisture content is lowest.

The trays of food may travel with or against the high-velocity air current, while counter-currents are quite often employed. The heat-exhausted air is used again and is treated to reduce its humidity before being reheated and once more employed. For the treatment of vegetables a modified form of tunnel drier is sometimes employed, the material being carried on endless conveyor belts through heated chambers at relatively low temperatures. The air is kept moving by means of circulating fans, the time of drying being adjusted by regulating the speed of the conveyor. Heat may be applied by means of steam pipes placed inside the chamber. A similar type of drier is also used for the dehydration of eggs, trays being provided for the carriage of the egg liquid when removed from the shells. *Roller drying*, both of the atmospheric and vacuum types, is used for the dehydration of liquids, particularly milk, while egg whites and yolks are often treated by the *spray-drying* process. When possible, the liquids to be dried by these methods are partially concentrated under vacuum, while the process of drying is often carried out under a partial vacuum so that the temperature necessary for the removal of moisture is reduced and chemical and physical changes thereby decreased. These last two methods of treatment have already been considered in relation to milk on pp. 259 and 261. The method employed in the treatment of foodstuffs is materially the same. *Centrifugal driers* are used for the dehydration of some food materials. The drying methods employed vary as mentioned above. Whatever method is used, it should be carried out so that spoilage from bacteria, yeasts and moulds does not occur during processing. Enzymic action must also be controlled. The colour or flavour should be retained. As only moisture is removed, the articles, when rehydrated, should be approximately normal in appearance. Good keeping qualities result when suitable treatment is applied.

Various *temperatures* are employed in the dehydration process, and their control is most important. If due care is not exercised the rate of moisture evaporation from the surface of the material being treated is greater than the speed at which the moisture from the interior of the substance is drawn towards the surface. The external surface may thus become hard and relatively impermeable, while further moisture removal will be virtually impossible. In addition, rehydration of the product by the consumer is rendered more difficult. While food should be dehydrated as quickly as possible, it is important that the physical and nutritive properties should not be injured in any way. For this reason the relative *humidity of the air*, its *velocity* and the *time of exposure* of the material to the heated air assume great significance. A suitable combination of these factors is essential if the process is to be wholly satisfactory, and many engineering problems are involved. Only by a thorough understanding of these principles can the producer of dehydrated foods ensure that the final product is generally satisfactory.

In considering the *application of the process* to the various materials treated it is important to remember that dehydration does not make poor food any better than it would be in its natural state. For this reason careful selection of the food to be treated is important. The quality should be at least as high as that acceptable for normal table use. The preliminary treatment should be carefully supervised and should be carried out in a thoroughly hygienic manner, the utensils employed being such as will assist in obtaining the best possible results. A number of different types of driers and methods have been used for the dehydration of *meat*, beef and pork being treated by this process. The beef is first cut by a rotary cutter and then passes to a cooking kettle where it is processed for twenty minutes or more at temperatures between 160° F. and 175° F., mechanical agitation being provided. The cooked meat is then ground and is carried to a tunnel drier. Pork is pre-cooked for one and a half to two hours, is ground and then dehydrated. The moisture content of the dehydrated meat is approximately 5 per cent. Vitamin B_1 suffers most in the pre-cooking and dehydration processes, but generally the vitamin losses are similar to those experienced with the household cooking of meat. When *milk* is to be dried the method employed is relatively unimportant, provided that a high-grade liquid of suitable bacterial and chemical quality is used. The methods of treatment have already been considered in greater detail in Chapter XVI. It remains only to state that, if the process is properly carried out, either by the roller- or spray-drying method, the relative nutritive value is practically unimpaired.

Various *dried egg products* have attained considerable prominence during recent years, although they had been used by confectioners for some time previous to the War. The whites are normally fermented before being dehydrated by the same process so that they possess better whipping qualities. Albumin from eggs is produced both by spray and tray driers, the latter travelling through a warm air current. Dried whole eggs are produced by means of roller driers, a modified form of tunnel drier being also used. The nutritive value of the protein and the fat of eggs does not apparently suffer by the drying process. Vitamins A and D are unaffected but there is a 30 per cent. loss in the vitamin B_1 content. *Potatoes* are usually dried in the form of flour by means of spray driers, to be later utilised by bakers, caterers and for reconstitution in the home in the form of mashed potatoes. The vegetables are washed and cooked with superheated steam. The skins are removed, and they are then well mixed with water to form a creamy liquid. This hot liquid is atomised by means of high-speed disc sprayers into a fine mist, which is discharged into a chamber in which a high-velocity heated air current is maintained. Immediate drying takes place. The potato particles fall to the floor of the chamber, from which they are removed by means of a heated air blast. They travel to a conveyor belt, which carries them to a sifting apparatus, after which the material is ready for packing.

The process of drying *vegetables* has not reached any great proportions to date. Vegetables which are to be dried are trimmed, peeled if necessary, and often washed. Great care is taken to select materials of the same size to ensure that the final product is uniformly dried. With the exception of peas and spinach, which are dried whole, the remainder of the vegetables treated in this way are either cubed, sliced or shredded. To prevent deterioration after processing due to enzymic and other changes, the vegetables are then blanched, being treated with steam or boiling water for several minutes to inactivate the enzymes and expel the oxygen from the tissues. Darkening or discoloration is prevented, the natural colour being preserved, while storage life is prolonged and reconstitution facilitated. The soluble constituents are coagulated and their loss prevented together with loss of vitamins. The escape of moisture during drying is facilitated, but the process is not carried on for a sufficient length of time to cook the vegetables ready for consumption without further treatment by the purchaser. Vegetables are dried at temperatures between 135° F. and 160° F. according to type, the process occupying between five and fourteen hours. The resultant article is dry and brittle and has an average moisture content of between 5 and 10 per cent. The operations preliminary to drying should be carried out as quickly as possible in order to prevent enzymic changes, bacterial development or loss of colour. The use of steam for treatment prior to drying prevents, to some extent, any loss of the mineral content.

Equal speed during the preliminary operations is necessary when dealing with *fruit*, which has to be cored, peeled, pitted, washed or trimmed according to type. The fruit must be carefully sorted as regards soundness, as bruised fruit tissue is difficult to dry and is susceptible to decay and discoloration. Most fruits are dried whole. In some cases, e.g., apples and rhubarb, the fruit is sliced. Peaches, apricots and pears are dried in halves. The preliminary treatment varies. Figs, grapes and plums which are to form prunes are treated with boiling lye solution ; cherries and rhubarb are steamed, while apples, apricots, bananas, peaches and pears are treated with sulphur. The use of sulphur prevents loss of flavour and discoloration, to which fruit is subject when exposed to air. It also destroys any insect life which may be present in the substance, while the bacterial content is reduced, souring prevented and insect infestation after dehydration mitigated. Sulphur is also stated to assist the drying operations by facilitating the escape of moisture. The prepared fruit is laid on trays and treated in small chambers with sulphur dioxide. In the case of sun-dried fruit more stringent sulphur treatment is applied. The sulphur dioxide may be generated by burning the chemical or may be obtained from cylinders of compressed gas. In some cases the fruit may be dipped in a solution containing alkaline bisulphites. Exposures up to half an hour are given. The use of sulphur dioxide is stated to preserve the vitamin C content present in the treated fruit. The amount of sulphur used and the length of treatment depend to a considerable extent upon the ripeness of the fruit. As the sulphur is steadily lost during storage an initially heavy dose is usually given, in the region of 2,000 to 3,000 parts per million. This allows for prolonged storage. After the preliminary treatment is complete, the fruit is dried at temperatures between 135° F. and 180° F., the time required varying from six to thirty hours according to type. The original moisture content is reduced to between 5 and 20 per cent., the final product varying in appearance from an extremely dry article, as with apples, apricots and peaches, to a slightly moist article, as with figs and prunes. Keeping qualities naturally vary but are satisfactory in every case if proper treatment is applied.

Storage of dehydrated foodstuffs when the moisture content has been removed is extremely important, as some portions of the foodstuff may be over-dried, whilst others will contain too much moisture. The dehydrated product is bulked in suitable containers and held for several weeks at room temperatures, so that the moisture content is equalised. This process is termed *curing* or *conditioning*. As a result the moister portions of the product yield some of their moisture to the drier portions, so that the quality of the whole is more uniform. Large bins are used for this purpose. These bins should be specially prepared to protect the foodstuffs against vermin, insects, moulds and bacteria. The entrance of moisture must also be prevented so that fermentation or decomposition does not occur. Fumigation by means of ethylene oxide, carbon bisulphide or carbon tetrachloride is often employed to prevent the depredations of insects, more especially the Indian meal moth (*Plodia interpunctella*), the saw-toothed grain beetle (*Silvanus surinamensis*) and the dried-fruit beetle (*Carpophilus hemipterus*), all of which cause considerable damage, particularly in dried fruit. Hydrocyanic gas was formerly employed for the same purpose. As this gas may be retained in the material in dangerous quantities, its use has now been discouraged. Dry heat at temperatures of 125° F. to 130° F., applied for several hours, will destroy all insect life in dehydrated products ; moist heat is not so successful. The infesting organisms lay their eggs in the food materials ; the development of worms and larvæ will render the food unfit for human consumption. Careful inspection of all dehydrated products for insect infestation is essential, a hand lens being useful for this purpose. Dried foodstuffs may decay due to the action of bacteria, moulds or yeasts. Brown mould rot commonly causes decay in stoned fruits. The decayed portion is difficult to detect after the fruit has been treated with sulphur. Fermentation causes portions of the material to darken. Owing to the difficulty with which moisture is removed from the affected portions, the darkened areas may be sticky to the touch. This defect may be caused by packing fruit in too moist a condition. Cool storage is essential in such cases.

After a period of storage the foodstuffs are ready for packaging, boxes and other types of containers being used for this purpose. Wooden boxes are generally lined with several layers of waxed paper in the case of fruit. The dried product is forced into the boxes under pressure. This helps to prevent penetration of air and insects and ensures uniform distribution of the moisture content. Individual packages containing sufficient for quick use are generally employed in the case of dehydrated vegetables. All packages should be moisture and insect proof to prevent the risk of spoilage. In the case of powdered milk and certain other dehydrated foods, the containers must not only prevent the entrance of moisture and insects but should guarantee the exclusion of air if lengthy storage is required. Such articles are usually packed in metal containers which are vacuum processed. Moisture-resistant packages are essential for dried fruits.

The *composition of dried fruits and vegetables* varies considerably. All *fruits* contain a certain proportion of roughage or unavailable carbohydrate. The available carbohydrates, which are present in quantities approximating between 40 per cent. in the case of prunes to 65 per cent. in the case of sultanas, are of the greatest importance from the nutritional point of view. The protein content varies from 1·1 per cent. in the case of raisins to 4·8 per cent. in apricots ; while the mineral matter, which includes calcium, iron, copper and phosphorus, may also vary considerably, the calcium content of figs being particularly high. Apricots and peaches contain most phosphorus ; copper is present in an appreciable quantity in peaches. Apricots, prunes, peaches and figs show the highest iron content. As dried fruits are either consumed uncooked or in the form of stewed fruit, there is no loss of mineral matter in discarded liquor as is the case with vegetable water.

Many dried fruits have an appreciable vitamin content. Vitamin A is present in reduced quantities in all fruits of this type to a varying degree, but apricots, peaches and prunes are deficient in vitamins B_1 and G, although the latter vitamin is present in prunes. Peaches, prunes and apricots also have a moderate vitamin C content. The employment of sulphur in the treatment of fruit before it was dried was formerly thought to exert a harmful effect on the consumer. Later experiments have not substantiated this opinion. The presence of sulphur compounds has been shown to act as a protection to vitamins A and C during cooking. Lye dipping, which is used to remove the skins of some fruits, assists in preserving vitamins A, B and C, which are destroyed by oxidation during drying if the period occupied by the process is extended. Quick dehydration at high temperatures appears to be least harmful to the vitamin content. *Vegetables*, particularly those of the leguminous type, contain a high percentage of protein, together with carbohydrates, mineral matters and small quantities of fat. The carbohydrates and the mineral salts may be materially decreased during cooking operations, a substantial proportion of these substances being lost in the cooking liquor when it is discarded. The vitamin content is often materially reduced during cooking.

The *nutritive value of dried fruits and vegetables* depends upon the methods of processing and cooking prior to consumption. The value should compare favourably with that of the original article if dehydration has been efficiently carried out, since only the moisture content has been removed. In regard to *fruits*, vitamin A is retained to a greater extent in apricots and prunes when treated with sulphur. Peaches are not materially affected. Raisins and figs retain their vitamin A content more abundantly when dehydrated, the loss being greater in sun-dried fruits than in others. Sulphur assists in the conservation of this vitamin in all cases. Dates are not adversely affected by any form of treatment normally employed. When sulphur is used in processing, vitamin B_1 appears to be almost entirely destroyed ; it is, however, substantially retained in unsulphured fruits. Vitamin G does not appear to be affected by any form of treatment. The vitamin C content may be variably affected, being completely lost when the fruit is sun-dried or dehydrated unless sulphuring is employed. In the case of prunes, lye dipping assists in vitamin C conservation, although it must be remembered that dried fruits are not prophylactic against scurvy. So far as many *vegetables* are concerned vitamin A seems to be comparatively unaffected. The same may be said of vitamins B_1 and G, although little is known of the full effects of the process on the two latter vitamins. Vitamins are almost entirely destroyed when onions, leeks, potatoes and carrots are dehydrated. It is important to bear in mind that methods of preparation for the table are important, not only for conservation of vitamins which remain in dehydrated foods but also as regards the remaining nutritive constituents.

The *bacterial content* of dried foodstuffs varies considerably. Various types of *non-pathogenic organisms* in the original fruits and vegetables may be present, even in increased numbers. The number present may vary from several hundred to as many million, depending upon the degree of handling of the substances before and after dehydration. Lack of hygienic methods result in a substantial increase. Similarly, moulds and yeasts may survive processing, while *pathogenic organisms* have been found to survive the dehydration process and to exist for long periods owing to fluctuations in temperatures and methods employed. Development of pathogenic organisms is also encouraged by unsatisfactory handling by infected persons after processing. Very little *epidemiology* has been reported in connection with dehydrated fruits and vegetables. Such cases as have occurred were almost entirely due to infection caused by unhygienic methods employed in packaging after drying. Dates and peas have been implicated in this way. The former use of hydrocyanic gas as a preventive against insect infestation has caused illness in certain cases following consumption of fruit treated in this manner. Hydrocyanides are not now employed for this reason.

The *control* of dried fruits and vegetables is based mainly on inspection of methods of production and of the foodstuffs concerned. Preparation at all times should be carried out under thoroughly hygienic conditions, which should be the subject of frequent supervision. Methods of handling should preclude the risk of infection from either plant or personnel. The producer and his staff should realise that the product must be delivered to the consumer in a clean, wholesome condition. As is the case with all other foodstuffs, the health of the personnel is of supreme importance if infection after dehydration is to be avoided. Dehydrated foods should invariably be condemned when found to be mouldy or fermented. This should also be the practice when extraneous dirt, insects, larvæ or spray residues are detected. Excessive quantities of foreign matter are frequently found in imported dried fruits which have been dried in the sun in tropical or subtropical countries. Arsenic or lead may be present in excess due to the employment of spraying substances, while excess sulphur has been found following the use of this chemical as a means of rejuvenating old or spoiled dehydrated foodstuffs, particularly fruit. An excessive amount of zinc may be present as the result of contamination from drying trays.

When exposed for sale, dried fruits should be protected from air-borne and other forms of contamination. They become sticky when exposed to the atmosphere. This facilitates contamination by dust and dirt, which will adhere to their surfaces. All dried fruit should be thoroughly washed before being consumed. The use of transparent wrappers or cartons is hygienically desirable. The employment of preservatives in dried fruits and in vegetables has already been considered on pp. 346 and 363. General control measures should be similar to those in use for the same substances in their natural state.

CHAPTER XXV

FOOD PRESERVATION (2)

Canning

SINCE the early efforts of Appert in 1795, which were designed to find a method by which food could be preserved for future consumption, the canning of various food products has made very substantial progress. In this country, the use of iron containers for food preservation was first patented in 1807 by a firm at Dartford, Kent, but the industry developed slowly and meat seems to have been the only food substance thought worthy of canning. The great American canning industry was not founded in Chicago until about the year 1870. Early in the present century canned food was viewed with suspicion. There has been a gradual change of opinion as to its merits and qualities, and for the last twenty years canned goods have been recognised as a valuable addition to normal diet. The canning of food has exerted considerable influence upon the food habits of all civilised peoples, since it is now possible to enjoy a variety of appetising and nutritious articles of diet, produced in any country at any time regardless of season. The flavour and texture of canned foods are now very high, while nutritive values are practically unimpaired. Cost is not exorbitant, as foods can be packed when they are plentiful and the price low. The cost of canned foods is also influenced by the fact that no cleaning, preparation or, in many cases, cooking is required. At most, cooking is reduced to a brief heating of the can and its contents in hot water.

All common fruits and vegetables can now be canned, together with meat and fish and their products. Syrups, preserves, milk, cereal products such as spaghetti, cheese, tea, coffee, sweets and puddings are also treated in this way, together with various kinds of soups. It has been estimated that almost 300 articles of food may now be purchased in sealed metal containers, all of which can be stored for long periods. Certain *primary considerations* apply to foods treated in this manner. The cannery must be near the source of supply ; the raw materials must be speedily transported so that they reach the cannery in prime condition. Harvesting of the food should be controlled so that the resources of the cannery are not overtaxed. If this point is neglected, food may be spoiled through delays in handling. An adequate pure water supply is essential, as much water is required for maintaining hygienic conditions in the factory and for washing the food to be treated. Both chemical and bacteriological purity are essential. Apart from the pathogenic potentialities of impure water, the chemical quality must also be satisfactory, as excessive hardness, mineral content or objectionable organic matters may adversely affect the physical characteristics and flavours of canned foods. The disposal of cannery wastes, both liquid and solid, must also be carried out in adequate manner.

The *cannery premises* should be capable of being maintained in a thoroughly hygienic condition. *Lighting*, both natural and artificial, should be adequate so that dirt cannot escape notice. *Floors* should be impervious and well drained, while all *internal surfaces* should be perfectly smooth, impervious and easily cleansed. A high-pressure *water supply* is to be recommended, as the force of water under pressure will assist considerably in cleansing operations. *Cleansing operations* will also be facilitated if the necessary fixed equipment, together with water and steam lines, are readily available so that treatment of any portion of the plant can be carried out as required. Steam is also required for the *sterilisation of plant*, although sodium hypochlorite solutions may be satisfactorily used for this purpose. The various articles of *equipment* required depend upon the foods being treated and the quantities to be handled and canned. Some equipment can be used for several types of food, while certain foods call for special apparatus. Washers, graders, trimming tables and fillers are necessary for all types of foodstuffs. Excellent mechanical equipment is now available.

Just as important as the equipment, which should always be of the finest quality, is the *sequence of operations* and *arrangement of the plant*. The treatment of the various articles of food should be planned so that there is a minimum of delay in the flow of raw materials and in completion of the finished product, since delays imply a lower production schedule and an inferior article. *Tables* for preparation and handling are designed for various types of food treatment. They should have impervious tops, preferably with a porcelain or stainless steel finish. They should be provided with an adequate pure water supply and waste pipes, together with conveyors to carry the raw materials to and from the tables and to deal with the filled cans travelling for sealing or inspection. *Filling machines* are used for packing the majority of food articles. Fruit is almost invariably filled by hand, although this is not so in every case. Exhausting, closing, processing and cooling devices are also essential. *Exhausting* the cans is usually a continuous process, particularly if large numbers are to be treated. The open-top can is almost universally employed, except for the canning of meat and milk, when the solder-top type is often used. Double-seaming equipment for *sealing* cans is so efficient that solder-top cans have virtually disappeared. With open-top containers the cover and body are rolled together under pressure, sealing compound being applied during the process. Up to several thousand cans per hour can be handled. Cans may be sealed within a vacuum chamber, an inert gas being introduced, if desired, in place of air. Mechanical exhausting and sealing is rapidly replacing the exhaustion of cans by means of heat. Various types of *processing apparatus* are used, either of the simple batch or of the more complicated continuous type. Almost any desired requirements can be dealt with, while time and temperature control is accurate. Agitation and equalised container pressure can be supplied as required. Cooking and processing are carried on simultaneously, after which *cooling* by means of the batch or continuous method completes the process.

Operations at the cannery usually follow a strict sequence. Food substances are first submitted to a *grading* process in order that the final product may be uniform in appearance, flavour, nutritive value, quality and soundness. Strict uniformity is, however, almost impossible owing to variations in composition and texture of the articles dealt with. Careful inspection of the incoming raw material is necessary to ensure that only the finest quality is used, as a satisfactory final product cannot be obtained if the raw materials are in any way sub-standard. Variations in raw fruits and vegetables may not be very noticeable when consumed in that state but may be quite obvious after they have been canned.

Articles are separated for size. It should be borne in mind, however, that size is no indication of quality, as large articles may be coarse and deficient in edible qualities. When fruit is packed, large sizes are preferable ; with vegetables small sizes find most favour. When the articles are packed whole, sizes may be mixed. When large bulk has to be handled, mechanical separation or grading by means of rotary screens, tapered rollers, tubes, gravity, vibrators and other devices is employed. The incoming material must be carefully examined for unsoundness. Materials so affected, together with immature or over-ripe materials, must be discarded. Some of the more decomposed parts may be removed during washing operations, while a final sorting by hand may be necessary to ensure that defective articles, such as those infected with insects or fungus, are removed. Hand sorting is particularly important where fruit is to be automatically manufactured into pulped products. When fruit is canned whole, unsound parts can usually be discarded, as trimming is then a manual operation. It should be noted, however, that in the trade grading may refer not only to the size of the articles canned but also to the different concentrations of syrups employed, particularly in the case of berried or soft fruits. Upon the grading process and the skill with which the various articles are sorted and trimmed depends the final appearance and quality of the canned product. The recognised grades of canned fruit are *fancy*, *choice*, *standard*, *seconds* and *water grades* ; for vegetables, *fancy*, *standard* and *seconds* are the usual grades. In addition to these main grades, sub-divisions based on *colour*, *size* and *variety* are also found, so that each main grade may be divided into several sub-grades, a point well-known to the trade but not to the consumer.

The *washing* of articles undergoing treatment is very important. This removes dirt, micro-organisms and other foreign matters. The success of the final heat treatment substantially depends upon the adequacy of the washing process, as the processing treatment must be lengthened if large numbers of micro-organisms are present. Effective washing removes many of these organisms, particularly from decayed portions or crevices in the substance. Prevention of disease is very important, and clean, sound raw material is required for the effective elimination of botulinous outbreaks from commercial canned food. Where dirt is dried on, as is often the case with root crops such as carrots, a preliminary soaking may be necessary, the material being submerged in water, where it remains for periods ranging from a few seconds to several minutes. Preliminary soaking assists subsequent washing operations, as the dirt is loosened and more easily removed.

Various types of apparatus have been devised for washing purposes. *Spray-type washers* are usually employed and are extremely efficient. The water sprays or jets can be closely controlled according to the type of article being dealt with, pressures from several pounds per square inch up to 60 lb. per square inch or even more, from adjustable spray nozzles, being employed. All crevices are thereby penetrated and the dirt removed, while the correct treatment is given to each class of article. *Rotary washers* are also employed. These apply friction, which assists in loosening and removing extraneous matter. *Compressed-air washers* may be used. By this means the water and contents are agitated. Agitation by means of paddles is sometimes provided. Machines are usually designed so that the articles undergoing treatment are turned in order that all portions may be exposed to the cleansing treatment. In the case of leafy vegetables sand, gravel and loose earth are removed prior to washing by shaking over screens. A final rinse is usually given to all articles after washing operations have been completed.

The *peeling and trimming* of certain types of fruit and vegetables prior to canning is often a manual operation, paid for on a piece-work basis. In the case of firm fruits such as apples, tomatoes and beetroots, however, mechanical peeling and coring equipment is available for large-scale production. These articles often receive a final trimming by hand to remove the skin from depressions and from other parts missed by the machine. Lye or caustic soda solutions are almost invariably used for the peeling of certain fruits on a commercial scale. Peaches, apricots, figs, young carrots and potatoes are treated in this way. The white membrane can be detached from the pulp of grape-fruit after the skin has been removed by the application of this liquid. Caustic soda or sodium hydroxide readily attacks plant tissue and causes its dissolution. The process must therefore be carried out rapidly, the unwanted tissue being removed by washing before the remainder of the substance is attacked.

Two methods of *removal* are employed. The material to be treated may be mechanically dipped in a bath containing a lye solution of 1 to 3 per cent. strength. This strength is slightly increased when the spray method is employed. The solution is maintained at a temperature as near boiling point as possible so that the most vigorous action can be obtained. The normal period of exposure is approximately half a minute, the time varying between twenty and forty seconds according to the article being treated. This treatment causes the skin to loosen, although the product is not damaged in any way. Boiling water is sometimes applied for a few seconds as a preliminary to treatment with lye, so that no chilling of the solution occurs when it comes into contact with the material to be treated. After treatment with the solution the material is subjected to fresh, clean water sprays. These remove all cauterised tissue and adherent lye, so that its continued action is prevented. Extended application of the solution causes fruit to become brown in colour. This change can be prevented by a short period of steaming or blanching. When properly used, no harm is done to the fruit, always provided that (*a*) the solution is of the correct strength, (*b*) that exposure is not too long and (*c*) that a thorough washing of the material is provided immediately after application of the chemical.

Many raw vegetables and some types of fruit are subjected to a *blanching* or pre-cooking process after they have been cleaned, sorted and trimmed, in order to improve their appearance and to facilitate packing. Hot water or steam is used for this purpose. In the case of young peas hot water removes the dirt and sticky coating, which would cause a cloudy liquor in the can ; older peas are softened by its use. The tissues of bulky greens such as spinach, asparagus and beans are either collapsed or the materials are rendered pliable, so that the can may be properly filled. Dry beans are treated in this way so that they may become plump by the absorption of water, while the process prevents discoloration of certain vegetables and fruits before packing takes place. Fruits are rendered more flexible for packing, while cherry skins do not exhibit the same tendency to split. Certain flavours and odours are eliminated. Heating the product in this way enables a partial vacuum in the container to be produced when the canned material has cooled. Air is also removed from the tissues. This not only assists in increasing the keeping quality but improves the appearance of the article so treated. As a result of the blanching process a certain loss of nutritive value occurs, particularly as regards the mineral salts, which are soluble in water. There is also some reduction in the percentage of the less stable vitamins present. Blanching, however, has so many advantages that any slight losses which occur in this way are outweighed. On the other hand, the immersion of vegetables into boiling water, which results in the rupture of the external cells and loss of their contents, does not appear necessary. Equally good if not better results can be obtained at lower temperatures with less nutritive loss. Steam has also been used for blanching, but not with any degree of success.

The *cans* used in the canning industry are produced from tinplate manufactured from rolled mild steel and coated with a thin film of tin. This coating is not by any means continuous. Minute bare spots are very often left, to become the foci of rust at a later date, particularly when the containers are stored under damp conditions. As this applies also to the internal surfaces, some type of protective enamel or lacquer—particularly synthetic resin—is applied, the material being baked on to the tinned steel at high temperatures. With certain types of food, the employment of these materials preserves the natural colours and flavours which might otherwise be lost in the untreated can. On the other hand, perforation of the can, or " hydrogen springers," occurs more readily in the case of certain fruits when the can is lacquered. When the tinplate is fabricated into a can care is necessary to ensure that the tinned coating is not cracked. If the metal underneath is exposed, it may be acted upon by the contents. Cracks most usually occur along the seams of the container.

Three types of can are employed. Meat is generally contained in what is known as the *solder-top* or *hole-and-cap can.* This is closed by sealing the top to the body with a soldering iron after the cans have been filled. Due to the somewhat restricted opening at the top, the can is difficult to clean, while contamination during soldering may ensue. *Vent-hole cans* are used for milk, being filled through a small vent-hole in the upper surface. For most articles the *open-top* or *sanitary can* is now generally used, the lid being fixed to the body after the can has been filled. The top is completely open, the closure being sealed on to the body of the can by rolling or crimping the edges together by machinery under strong pressure. A sealing compound in the top rim forms a hermetically tight closure. The absence of solder is important in cans which are used to contain fruit. Although the production of cans is automatically carried out, they may contain dust, insects or other foreign bodies. It is most important that these substances, when present, should be removed before the container is used for food. *Can washing* should therefore be regarded as an essential process. On their way to be filled, cans should be inverted to dislodge any foreign matters. They should then pass to the washing machine.

The *filling* of the cans is usually combined with the grading of the article. Hand filling is used in the smaller factories. When large quantities are to be handled, automatic apparatus is employed. This discharges the required quantity of material into the cans, which move on conveyors to the filling point. In the case of fruit and vegetables, and with some types of fish, the cans pass forward to be filled with syrup, brine or water. Hand filling is often required in the case of fruit when the cans are required to hold a certain number of pieces. *Meat* is usually placed in the cans by means of a rotary stuffing machine. A liquid meat jelly is added afterwards. This solidifies on cooling to act as a binder, improving the appearance and palatability of the meat. *Fish* is packed either by hand or automatically, oil or brine being added to the contents. High-quality *fruit* is packed in syrup. Syrup is essential when acid fruit is dealt with, imparting the necessary sweetness desired by the customer. Fruits for manufacturing purposes are generally packed in water. The natural fruit flavour is preserved by the use of syrup, while metallic flavours due to interaction between the fruit acids and the metal of the can may be masked by its use. The colour of the fruits is also fixed and bleaching prevented. In addition the fruit tissues are prevented from disintegration, particularly at the edges or cut surfaces. A heavy syrup is essential in the case of soft or fragile berry fruits for the same reason. Heavy syrup also prevents mechanical injury to the contents of the can during transport.

Syrup of varying densities or containing different sugar percentages is employed, according to the grade of fruit being packed, the best type of sugar, either cane or beet, being used in syrup production. Corn sugar is also employed for this purpose. The sugar syrup is often purchased in ready-made form for immediate use in order to save the cost of preparation. The water used for syrup making must be pure and as free as possible from mineral matter, so that a bright, clear liquid is obtained. After production the syrup is usually stored in tanks varying between 500 and 1,000 gallons capacity, whence it is drawn in a warm condition by means of galvanised iron or stainless steel pipes to the filling machines, which discharge it into the cans in the correct quantities. Where the density is such that the syrup must be diluted with water, this is carried out by means of a slight adjustment to the filling apparatus. This method allows syrups of varying densities to be provided from one storage tank containing a liquid of standard density. It is important that syrup tanks, pipe-lines and valves should be capable of being rapidly cleansed and sterilised to reduce the incidence of thermophilic infections. The longer the pipe-lines and the more fittings and valves being used, the more difficult will cleansing become. The greatest care must therefore be exercised throughout. Pipe-lines should be kept as short as possible, warm syrup favouring the development of heat-resistant organisms.

Vegetables cannot be properly packed without the use of *brine*, which is essential except in the case of peas, spinach puree, macedoine of vegetables and beans in tomato sauce. Brine should be produced from the finest-quality salt and soft clean water. The quality of the water is of the greatest importance. If its iron content is high or if it is excessively hard, certain types of vegetables, such as peas and beans, may be spoiled, either by becoming hard or by developing an undesirable flavour. Salt and water in correct proportions are mixed. The brine is boiled and passes to enamelled or glass-lined storage tanks. The quantity of salt called for varies between 1·25 and 2·5 per cent., 2 per cent. being the average quantity required for most vegetables. A higher percentage is often required where only a small quantity of brine is added to the can so that a desired flavour may be obtained. A small amount of sugar is sometimes added to the brine, particularly in the case of peas. Brine should preferably be weak rather than too strong, since excessive salinity cannot be removed although it is always possible to add further salt to vegetables prior to consumption. No colouring matters may be added to canned vegetables except in the case of butter beans, haricot beans, runner beans, peas and spinach.

Macedoine of vegetables must be packed in brine and the quantities of the various constituent vegetables are specified as follows :

Carrots (diced)	Between 25 and 45 per cent.
Turnips or swedes (diced)	,, 10 ,, 35 ,,
Peas	,, 15 ,, 36 ,,

The other vegetables which may be included, if desired, are :

Beans	Between 10 and 20 per cent.
Potatoes (diced)	,, 10 ,, 35 ,,
Stringless beans	,, 10 ,, 20 ,,
Celery	,, 4 ,, 8 ,,

Macedoine must not contain any vegetables other than those set out above.

The composition and descriptions of *canned soups*, of which there are innumerable varieties, are specifically laid down. *Meat soups* must contain not less than 6 per cent. of raw fat-free meat without bone, or its equivalent of dehydrated meat properly reconstituted. Meat extract, hydrolysed protein or yeast extract are not recognised as the equivalent of meat. Whalemeat may be used, provided that not more than 50 per cent. of the required meat content consists of this substance. Oxtail soup must contain not less than 2 per cent. by weight of whole oxtail including bone, while turtle soup should have a turtle meat content of not less than 6 per cent. by weight. In the case of mock turtle soup, the meat content must not be less than 6 per cent. by weight, excluding bone or fat, while if a soup is described as kidney soup, not less than two-thirds of the meat content must be kidney meat. The meat content of Mulligatawny soup must not be less than 6 per cent. by weight, while this soup should be flavoured with curry, and it may be garnished with a suitable cereal. A *cream soup* should contain not less than 3½ per cent. by weight of edible oil or fat. If a soup is described as *vegetable soup*, it should contain at least four different vegetables in equal proportions. If one vegetable predominates, the name of that vegetable should be clearly indicated in the title. In the case of such soup described under the name of a single vegetable, the bulk weight of this vegetable should exceed the total weight of the remaining vegetables used in its composition. Green pea soup should be produced from fresh green peas or from canned or frozen peas. If processed or dried peas are used, the soup should be described as pea soup so that there is no suggestion that fresh green peas have been used in its composition. *Clear* soups are obtained by the extraction of meat, by the dilution of a meat extract, or by the extraction of vegetables. They are sold as consommés and in a single-named meat consommé the named meat should be the predominant single ingredient. In addition to meat extract, Julienne consommé should contain between 3 and 6 per cent. of vegetables. *Broths* contain various types of meat or bone extracts, together with meat fibre, vegetables, spices, herbs and colouring and flavouring substances. A number of *miscellaneous soups* are canned, such as minestrone, produced from vegetables and a clear meat extract, with the addition of a macaroni product. Scotch broth must contain not less than 6 per cent. by weight of mutton, including bone or fat, or 3 per cent. boned mutton, together with barley and other vegetables, the whole being thickened. Mushroom soup must have mushrooms as the predominant single ingredient.

Exhausting must be carried out to remove the maximum amount of air from the cans, so that the internal strain or pressure during heat processing is minimised and a partial vacuum is produced in the can after cooling. This process may be undertaken either by the application of heat or by treatment with some form of mechanical vacuum. When heat is used, the filled cans are carried by means of a conveyor through an exhaust box in a steam-laden atmosphere. This raises the temperature of the contents and causes all gases to be expelled. Alternatively, the cans may pass, partly immersed, through a hot-water bath. The contents expand so that, when the can is sealed, a partial vacuum is produced on cooling. With hot-water exhausting, the heat can be more closely regulated at a lower temperature than is the case when steam is used. Heating is also more rapid and uniform. In practice quick exhausting is usually carried out but for delicate products such as fruit a slow exhaust is preferable. Varying temperatures between 180° F. and 200° F. are used, according to the type of product being treated. The period of exhaustion varies from three to eight minutes. Heat treatment during the process enables cans to be delivered for final processing at a uniform temperature. The remaining treatment is then more satisfactory, heat penetration being assisted by removal of the air, while excessive oxidation during processing and subsequent storage is reduced. The lack of oxygen also reduces the tendency of the food to attack the internal surfaces of the container, particularly in the case of fruit and vegetables. Overfilling is also prevented, as the contents expand during heating. Chemical action with the development of hydrogen swells is to some extent retarded, while internal pressures during processing are relieved. The reduced pressure causes the ends of the cans to become concave. This indicates to the inspector and consumer that no gassy fermentation has occurred to distort the can. Exhaustion by means of a vacuum process is also used, particularly in the case of fish. This method has made considerable headway in connection with other articles of food during the last few years. The cans are finally sealed when the exhausting process is complete.

After sealing, *processing* is required, not only to cook the contents of the can but also to prevent spoilage of the contents by any micro-organisms which may be present. Although most of the bacterial forms present are destroyed, the cans and their contents are not always sterile. Obviously injury to the contents by overheating must be avoided so far as is possible, but it is usual to attempt to balance long-keeping quality with the retention of the nutritive value. It should be remembered, however, that bacterial spores may be present which are so resistant to heat that their destruction would require the application of temperatures which would render the food uneatable or at least unsaleable. The temperatures employed in processing and the duration of the process are determined by a number of factors. The *type of food* is important because of the effect of different temperatures on the food and the manner in which the food reacts to heat treatment. Temperatures in the region of boiling point are used in the treatment of fruit, sterilisation being extremely rapid. If higher temperatures are employed the flavour is quickly altered, some fruits being more susceptible than others to the effects of heat. Lower temperatures, in the region of 175° F,, have been the subject of experiment and appear reasonably successful. An exception must be made in the case of pineapple processed under pressure, temperatures of 220° F. being used to improve the colour. Acid fruits are processed at temperatures in the region of 190° F. to 212° F., while meat and vegetables are treated at temperatures in the region of 240° F. to 250° F. for twenty minutes, higher temperatures producing a dark coloration, a scorched flavour and strong odour. Milk can withstand high temperatures without physical injury, as will various types of meat. Fish varies in this respect, some types being more susceptible to heating than others. The temperatures employed must be sufficient to destroy any organisms present but must not cause objectionable alterations in the food so treated.

The *types of organisms* must also be considered. Processing methods and temperatures are usually determined by the organisms likely to be found in or on a given article. No two articles are alike in this respect. An instance of this is *Clostridium botulinum*, the death time of this organism being 100 minutes at 221° F., or ten minutes at 239° F. This period is now universally accepted as the minimum processing time. The degree of infection which is likely to be present either due to conditions of growth or handling after production is important. Various foods are therefore given different treatments, it being the custom to ensure that the majority of heat-resistant strains of organisms are destroyed during processing. To destroy all of them in every case would require temperatures which would render the foodstuff unpalatable. The *degree of acidity* present affects the process. The greater the acidity the more readily is sterilisation carried out, so that lower temperatures can be used. For this reason vegetables which are normally less acid require more prolonged treatment at higher temperatures. Exceptions exist, however. To ensure adequate treatment it is usual to obtain the pH value of the product, so that suitable processing is assured. The *degree of infection* likely to be present must also be borne in mind. This is likely to increase if delay between harvesting and canning occurs, particularly if the food is exposed to unsatisfactory handling prior to arrival or at the cannery. Under such conditions more lengthy processing may be necessary to ensure safety, with the production of an article as nearly sterile as possible.

The *initial temperature* of the article immediately prior to processing is also important. The temperature at which the product is heat exhausted and the speed with which it is subsequently processed must be taken into consideration, so that heat loss is reduced to the absolute minimum. Rapid losses in temperature will affect the subsequent processing if the period of treatment is short. A high uniform temperature should therefore be maintained at all times. The *degree of heat penetration* is yet another significant factor. Heat transference is always more rapid in cans which contain liquids than is the case with solid substances such as meat. Quick sterilisation together with adequate time and temperature are important to ensure the penetration of sufficient heat to every part of the product.

The position of the can in the steriliser exerts an effect upon heat penetration. This has been proved by experiment, and is particularly significant in the case of milk. Steam should be kept freely circulating in the apparatus so that no pockets or cool areas are present. Closely linked with the problem of heat penetration is the *size of the can*. Larger cans require longer treatment if every part of their contents is to be adequately processed. The *method of cooling* must also be taken into consideration. The employment of latent heat, as in slow cooling, is likely to lead to subsequent spoilage. Rapid cooling is therefore to be preferred. Indeed, it is virtually a pre-requisite to success. During processing the cans are placed in iron crates, which are lowered into the processing kettles or retorts. Alternatively, the crates may be wheeled into a steam chest fitted with a tightly-closing door. High-pressure steam is then admitted to raise the temperature to the correct point. This temperature is maintained until treatment is complete. Air pockets in the retort must be avoided and the distribution of heat must be uniform. Agitation is sometimes employed during processing to ensure more uniform treatment. The *heat of exhaustion* must be considered, particularly when fruit is being handled. Soft varieties of fruit will be seriously damaged if heat is too rapidly employed, while gentle agitation is also necessary with soft fruit. Whilst steam is commonly employed for processing, some canners prefer to use water heated by means of steam. Whatever the method used, the adequacy of the treatment is the prime desideratum.

The need for rapid *cooling* has already been emphasised. When the cans have been removed from the steriliser, they must be cooled immediately, water being usually employed for this purpose. Batch cooling, either in a retort or open vat, may be carried out by the introduction of water from the base, or alternatively the cans may be sprayed from above. Some authorities prefer the first method, as the cans are prevented from buckling or developing leaks owing to the sudden reduction in temperature. The cans may also be cooled by passing through waters of varying temperatures. The employment of water sprays in the open is sometimes used, the rapid evaporation which ensues exercising a cooling effect. Air cooling in tunnels has also been employed, particularly in the case of fruit. By this means a deep, rich colour is obtained.

The time and temperature control of processing can be more accurately gauged when quick cooling is practised. The degree of cooling given varies with the product. In some cases it is sufficient to stop further heating of the material ; in others the cans are allowed to remain at a temperature sufficiently high to effect rapid drying. In the case of some foods atmospheric temperatures must be quickly restored. Cooling imparts to the food an improved appearance by ensuring a clear liquor and a good colour. It also prevents overheating of the hot cans, reduces the cooked flavour and obviates any tendency in the food to become soft. In addition, it retards interaction between the food and the container, relieves internal pressure in the cans and prevents the development of any surviving thermophilic organisms which may cause " flat sours " during storage.

Canneries usually maintain complete *records* as part of their routine operations. This practice ensures that the commencement and termination of processing, the temperatures attained and the point at which cooling began may be referred to in the case of any particular batch of cans. Coding numbers are sometimes added to the record, while automatic recording devices may be provided when continuous processing is carried out. *Coding* is a normal and most desirable practice. In order that the cans may be identified at a later date, code marks or numbers are usually printed on the side of the container when filled. Letters or numbers are used to indicate the product, the cannery, the year of canning and the grade. The month and the day of treatment are often added. Such markings are usually applied mechanically, quick-drying inks being employed.

In order that the containers may have an attractive appearance during sale, *cleansing of the cans* before labelling takes place is required. Cans may be cleansed by mechanical means, the ends being polished and the sides brushed. Those containers in which meat or fish is packed are often externally coated with grease or oil. These substances are usually removed by spraying with hot lye solution or by passing through a hot caustic bath. A final rinse is given to remove the degreasing solution. Cans used for meat and salmon are given a coating of coloured lacquer to protect the metal. Lacquers should be odourless, should dry quickly and should protect the can against rust. Fruit, milk and vegetable cans are rarely lacquered externally unless shipped abroad, when the process is carried out to prevent rusting. After cleaning, the cans are ready for labelling and packing. Until required for use they should be stored under cool conditions, in order to reduce risk of chemical action between food and container and to maintain the contents in a satisfactory condition. Careful *testing* of the cans after treatment is extremely important. Cans are usually stored for several days before packing at a temperature of 100° F., so that evidence of " swells " due to insufficient processing, of leakages or of other defects may be obtained. After incubation in this way the cans are examined. Those which show defects are discarded.

The *composition* of canned foods may vary considerably. While little change may occur, the analysis of a particular food when packed in syrup or brine may be considerably altered from the normal. Even the same type of food may vary in composition due to the conditions under which it is grown or obtained, essential differences in the same variety and the canning methods employed, particularly the temperature of processing. In most cases the composition is not radically altered, although there may be some reduction in vitamin content. The *nutritive value* of foods treated by canning is more important than the actual composition, although the relation between these two factors is naturally close. Changes occur in composition during processing. These changes are somewhat similar to those which occur when the same food is cooked normally, with certain very important exceptions. In ordinary cooking the food is in contact with the atmosphere during cooking, the cooking water is often discarded, while an open vessel is used. When canned foods are processed, the treatment takes placed in exhausted closed containers, the juices being retained in the cans. There is some loss, however, due to processing and, in the case of vegetables, by reason of the blanching process. It should be remembered that foods are normally canned at or near the point of production, so that the maximum nutritive value will probably be maintained. Thus, the food is not subject to the same nutritive losses which are likely to occur when the products have to be transported long distances in an uncooked state.

The valuable mineral constituents of food are unimpaired by the canning process. Indeed, these are more readily made available, as the tissues of the various products are more thoroughly broken down during the treatment. In the case of vegetables a minimum of liquid is present in the can, so that very little mineral matter is lost in the cooking liquid. The same principle applies to vitamins, particularly those soluble in water. Canned foods retain their vitamin A content to a high degree, as oxidation and enzymic activity are avoided during canning. Vitamin B_1 is partially destroyed in the canning of leafy vegetables, but no appreciable quantities are lost with other foods. Appreciable quantities of vitamin C remain after treatment, canned foods losing little of their vitamin C content during storage. When present in the original unprocessed food, vitamin D suffers little destruction. This particularly applies to canned fish. Canned food will remain edible and nutritious so long as the can remains sound, having been stored for surprisingly long periods without any sign of deterioration.

The *bacterial content* of canned food also varies. It should be borne in mind that absolute sterility is not possible under commercial conditions even when the container and the food may be sound. To ensure a sterile article excessive processing would be required. In turn this would appreciably reduce the nutritive value of the food or even render it uneatable. The survival of a few spores is not important, provided the spores do not develop during storage. All pathogenic organisms which have slight resistance to heat are destroyed during processing. Four bacterial groups which form heat-resistant spores can be present and cause spoilage in non-acid foods. Those which cause " flat sours " produce lactic acid without the formation of gas. No swelling of the can occurs. Gas-forming thermophilic organisms of the anaerobic type can produce hydrogen and carbon dioxide, which cause the cans to swell. Another thermophilic anaerobe is met with which produces highly soluble hydrogen sulphide. This combines with the iron of the can but causes no swelling of the container unless it is heated. A putrefactive type may also be present. This produces distortion of the can by the production of gas which has a putrid odour. In the case of acid canned foods spoilage is due to acid-tolerant bacteria which sometimes produce " hard swells," to yeasts and to organisms of the " flat sour " type. Under-processing or slow cooling are usually responsible for their appearance.

There is very little *epidemiology* to report in connection with commercial canned foods, which, owing to the processing received, are very probably the safest foodstuffs on the market. This has not, however, prevented blame being attached to canned foods in the past. If canned foods are in an unsound condition when eaten, if methods of processing are unsatisfactory or inadequate, or if canned food remains uneaten for several days under unsatisfactory storage conditions, then it is certainly possible for illness to occur. The possibility of the infection of canned food after the contents have been removed from the container should not be overlooked, and cases of infection have occurred from this cause. Savage has reported sixty-two outbreaks of illness due to canned goods out of a total of 203 reported outbreaks. It is interesting to note, however, that these are reports only. No details are given as to the respective cases. While organisms of the *Salmonella* group are destroyed by adequate processing and their growth on most foodstuffs does not change the appearance of the material, they do, however, irregularly produce toxins, some of which may not be destroyed by processing. It is these heat-stable toxins which are likely to cause illness. It must be admitted, however, that very little information on this subject is available. *Botulism* has been produced by canned foods, many such cases having been reported from America. The majority of these cases occurred in home-canned foods and were due either to under-heating or under-processing. Canned foods which contain the botulism toxin invariably emit an abnormal odour and may indeed be extremely obnoxious. The cans are usually swollen, while a cheesy odour may be noticed when the container is opened. No cases of botulism due to canned food eaten immediately the can has been opened have been reported for a number of years. When most foods are canned they dissolve some of the tin. This metal combines with the protein or some other constituent of the food to form an irreversible soluble compound which renders the metal harmless. The amount of tin present in the food varies with the acidity of the substance, the temperature and the length of storage, but, as already indicated, presence of this metal does not appear to produce any harmful effects. A metallic taste may develop in canned acid foods which are opened if part of the contents are allowed to remain in the can. This is due to the iron which has been dissolved by the liquor present. Apart from such taints, food left in the can will not be subject to any greater risk of spoilage than would be the case if it were allowed to stand in an open vessel.

Apart from the *control* of canned goods by the inspection of the articles and removal of defective or unsound cans, further consideration of which is given on pp. 398 to 401, supervision of the premises in which the process is carried out is of considerable importance. The raw materials must be sound before sterilisation takes place ; but the sterilisation process should never be regarded as a substitute for cleanliness. The *premises* must be maintained in a sanitary condition, with well-drained floors, smooth-topped and impervious preparation tables and arrangements for efficient removal of all waste matters from the processing rooms and premises generally. The *equipment* must be thoroughly cleansed as often as is necessary to prevent the development of those organisms which cause spoilage. Blanching apparatus is particularly important in this connection. Inspections should be made during operations and also when work has ceased for the day. Once it has been cleansed and sterilised, equipment should be protected from contamination until again required for use. The *water supply* must be pure, while adequate *cloakroom accommodatiom,* with a sufficiency of hot and cold water, soap and towels, must be provided. It must also be clear that the *personnel* are being required to use these facilities. Medical supervision of the health of the employees is important. They should be provided with and required to wear suitable overalls and head coverings. The National Canners' Association of America has adopted a Code of Practice which contains the following special provisions :—

(1) Containers must not be filled by dipping.

(2) Vessels used for food packing must not be used in cleansing operations.

(3) Cans and covers must be protected from contamination.

(4) All food products except cabbage must be washed before canning.

(5) Apparatus and utensils must be emptied and cleansed at least once daily.

(6) Refuse must be removed daily.

These requirements, which are to be highly recommended, are urged upon their members in addition to the usual sanitary requirements.

Bacteriological control of canned goods is directed towards the determination of organisms which may be present. Special media are used for the detection of organisms causing "flat sours" (dextrose tryptone agar), certain anaerobes (liver broth), putrefactive anaerobes (beef heart peptic digest broth) and thermophilic anaerobes which produce hydrogen sulphide (sulphite agar). An excessive bacterial, mould or yeast content, detected by microscopic examination, will show that spoiled or decomposed materials have been used. Insect infestation of soft fruits is determined in a similar way. On occasion examinations for the presence of food-poisoning organisms may be necessary. *Chemical examinations* include estimation of pH and of the moisture, total solids and acidity contents, together with determination of the metallic content and the gases, if such are present. An excessive quantity of hydrogen gas together with an abnormal metallic content indicates corrosion of the metal ; excess carbon dioxide is evidence of bacterial infection. *Biological examinations* by inoculation into guinea-pigs, mice or rabbits is employed when canned food is suspected of being concerned in a botulism outbreak.

Defects in Canned Goods

A normal can should possess a clean appearance, be free from rust and from stains and have slightly concave ends. Excessive rust may hide evidence of perforations through which spoilage organisms have entered the can, or through which gas from fermentive processes has been able to escape. Seams should be mechanically sound and free from leaks. Cans which have been dented by accident usually exhibit a compensating bulge at another point and may be quite sound. On the other hand, dented cans indicate rough handling, which may have weakened the seams and permitted the entrance of unwanted organisms. While the tinplate container can be satisfactory if carefully handled, being light in weight and strong and economical in use, it is not perfect. Defects may arise due to methods of fabrication or to faults in processing. For this reason canned goods should be carefully inspected. The inspector should examine at least 10 per cent. of any consignment of canned goods. If more than 2 to 2½ per cent. have to be rejected, every case in the consignment should be thoroughly examined. Danger from canned food may arise from changes in the condition of the contents, the use of preservatives or colouring agents and impurities such as tin obtaining entrance to the food from the container. Most difficulty is, however, likely to be experienced through lack of proper treatment during production.

Four *methods of inspection* should be employed. First a superficial examination should be made, followed by palpation, percussion methods and shaking. A *superficial examination* is primarily necessary to ensure freedom from indentations and rust holes and to establish whether any of the containers are " blown " or leaking. Stained cases usually indicate leakages in some portion of the contents ; " blown " cans are shown by the bulging of the containers. Rusty cans should always be carefully inspected, while second vent-holes must always be viewed with suspicion. A second solder hole is sometimes made during the normal process of manufacture. Second vent-holes, therefore, may not be significant provided the container appears otherwise sound. Cans should also be the subject of *palpation*, the fingers of both hands being used to detect bulging ends. When " blown," the ends are irreducible under pressure. Loss of vacuum will be obvious during this process, a distinctive springy feeling being readily noticeable. The employment of *percussion methods* provides a useful indication of quality, the can being tapped with the fingers or a piece of wood. If sound, the container will emit a dull note. A drum-like sound will be noticeable if gas is present. This sound may only be found by tapping certain parts of the can. Where the degree of abnormality is great the drum-like sound may be heard from every part of the container. Any can which fails to emit a dull note in every part should be rejected. Cans of meat are usually tested by *shaking*. When the contents are in an advanced state of decomposition, liquid is present. This is easily detected when shaking is carried out. Such cans should be condemned. If any doubt exists as to the wholesomeness of the contents as a result of external examination, a proportion of the cans should be opened. A decision can then more easily be made.

The number of *defects* to which cans are subject are many. The majority are due to faulty methods of production. *Poor flavours* may be noticeable in the finished product. Such flavours are usually acquired by the food before it is placed in the containers. Due to incipient fermentation, vegetables often have an acid taste, while they also develop bitterness owing to changes in their structure. This is particularly the case with asparagus and beans. A woody flavour in apricots and peaches is due to the wooden containers used for their transport prior to canning. The taint may suggest resin or turpentine. Fruits which have been cold stored before treatment may develop a musty taste ; extremes of storage temperatures cause flavour changes in the untreated fruit. The marking ink used for coding the cans had been known to produce a carbolic taint, particularly in fruit packed in heavy syrup. This is due to the phenolic odour of the ink affecting the contents prior to closure of the containers. When not specially prepared, the lacquer used for treating the interior of the cans has caused taints to develop in asparagus, beans and other vegetables, whilst unsuitable sealing compounds and gaskets may also affect the flavour of canned food.

Discoloration is due to a number of causes, the principal being contact with metals before the food is placed in the can or to interaction between the substance and the container. Copper is particularly liable to cause discoloration and may produce blackening of the food or liquid, especially milk or peas. Thus if copper is employed it should be well tinned. Iron exerts a serious effect upon fruit and should not be allowed to come into contact with it, glass- or porcelain-lined vessels being used. Stainless steel will also prevent any difficulty in this respect. Blackening may result from the formation of tannate of iron and is often noticeable in cans of apples, beans whose skins contain certain tannate-forming substances, strawberries and raspberries. Food may be discoloured during processing when high temperatures are employed, as the sulphur in the protein content may be broken down to combine with iron and form iron sulphide. This defect occurs in canned fish, white meat and in certain carcass meats, which become black on their external surfaces. Interaction between the food and the tinned coating of the container may also occur, a hydroxide of tin being formed during processing. This discoloration does not penetrate beneath the surface of the food as does that caused by the presence of sulphide of iron. Liners of parchment paper are used to prevent this defect, particularly in the case of crab, crayfish and lobster meats.

Bleaching occurs in the case of fruits such as cherries, raspberries and strawberries, and is due to reaction between the tin and certain contained pigments. The acid contained in the fruit acts upon the tin, hydrogen anthocyanin being liberated. This acts as a bleaching agent, rendering the food pale and unattractive. Excessive heating causes a *darkening* of the material ; in the case of canned pears a pink colour sometimes develops. Leaks cause the food to darken. Although discoloration due to bacterial action is not common, food subjected to such action is invariably darkened of blackened. The effects of *freezing* during storage must also be considered, particularly in the case of canned soft fruits and tomatoes, which are affected by excessive low temperatures. Vegetables such as asparagus and beans may also be damaged. While low temperatures during storage of raw materials are advisable, temperatures at or below freezing point should be avoided. What is known as *stack burning* is caused by storing the cans in an excessively warm condition after processing. If cans are stacked warm the contents may become semi-liquid, exhibit an offensive flavour and darken in colour, particularly those cans placed in the centre of the stack. The cans themselves take on a dull appearance. Tomatoes, peas and certain other fruits and vegetables may be seriously affected in this way.

Leaking cans are usually due to defects in sealing the containers, leakages occurring along the seams. The body of the can itself may be defective following the use of poor-quality or brittle tinplate, which has fractured during sealing operations. Small leaks are most serious, as the contained vacuum may be lost, causing deterioration of the contents due to infection by various organisms and the development of "swells." As the minute opening may be closed by part of the material in proximity to it, there may be no visible evidence of any loss of contents until the affected cans are moved. Cans affected in this way show loss of vacuum and may be rusty internally. The food itself may be seriously discoloured, while an analysis of the liquid contents may disclose the presence of abnormal quantities of iron and tin in solution. Extensive leaks are made quite obvious by the presence of liquid or stains on the cases. *Pin-holing* is due to localised chemical action of the food upon the can at points where the tinplating is imperfect or where it has been damaged in the fabrication of the container. Pin-holing also occurs where the metal has been fractured in closure or where the internal lacquer has been damaged. Chemical action is concentrated upon the affected point, usually in the production of a minute aperture through which the contained liquids may leak. The vacuum is lost and the contents deteriorate.

Flat sours are caused by inadequate processing or by failure to cool the can and its contents efficiently after treatment. Organisms develop and cause a certain degree of acidity or sourness, although gas is not produced. Most of the organisms causing flat sours grow at temperatures between 100° F. and 130° F., although they may occasionally develop at lower temperatures. These conditions may be caused by heat-resistant or thermophilic organisms. The can appears normal on inspection, but shaking may show that the liquid contents are in excess of normal. If an affected can is placed in warm water the ends will distend more quickly and collapse more slowly than normal when cooled. Cans placed in the interior of stacks are most often affected, particularly if they are stacked hot. This defect may be prevented by adequate processing and immediate cooling. *Swells* are caused by internal gas production due to the action of bacteria. Carbon dioxide is mainly involved. This gas may be mixed with a number of foul-smelling gases. The defect is due to infection through leakages, or to improper sterilisation. When an entire batch of cans is affected, the defect is usually due to inefficient sterilisation. The ends of the can become distended, while the quantity of gas produced may be sufficient to burst the can. The food is usually sour, offensive smelling and discoloured. Cans of meat affected in this way are usually known as "*puffers*."

Springers or *flippers*, as they are termed in trade circles, are due to minute leaks, to insufficient vacuum, overfilling or to interaction between the food and the container. Other causes are low acidity, faults in the internal lacquer, absorption of the tin salts by the contents with the exposure of the underlying iron, presence of sulphides which accelerate corrosion with highly-acid foods, inefficient cooling and storage at high temperatures. One end only may be distended. If pressure is applied the distension will pass to the other end. Both ends may be distended during high atmospheric temperatures, but the cans may revert to normal with a return to cool conditions. In some instances the internal pressure may be sufficient to burst the can. This defect may not develop for some weeks but is prevalent with certain types of acid fruits, the contents of the can remaining sound but not saleable. No organisms are present, although quantities of hydrogen gas are produced due to the action of organic acids upon the tin or iron. The hydrogen will burn if a light is applied to the can when punctured. An astringent flavour may be noticeable, while the contents exhibit a bleached appearance. Thorough exhaustion of the cans, cool storage and suitable internal lacquering will prevent this defect. The cans should never be overfilled. *Slack cans* are containers which have not been sufficiently filled. They are usually normal in appearance. The air in the can is sterile, although percussion may cause a sound to be emitted similar to that obtained from a " blown " can.

Glass Containers

The preservation of food in glass containers instead of in cans was gaining in popularity in this country prior to the War, and is likely to do so again in the future. The main type of foods treated in this manner are fruits and certain vegetable products. Some manufacturers re-packed imported meats from cans into glass vessels of various shapes. This practice is not one which is likely to enhance the confidence of the consumer in this type of packing. The use of glass containers has the advantage of ensuring freedom from any possibility of metallic contamination, while the condition and, to a lesser extent, the quality of the food are visible. From the processing point of view, vacuum-sealing apparatus is not required. Glass containers are, however, much more expensive and are more easily damaged. Any damage which occurs may result in the entrance of glass splinters into the contained food.

The preparation of food for packing in glass containers is essentially the same as that required when goods are to be canned, except that, if possible, greater hygienic care in handling at all stages is necessary. The main difficulties are experienced in sealing the containers and in their adequate sterilisation. A reliable air-tight seal between the metal lid and the container is difficult to obtain. This problem is usually overcome by the use of a rubber washer between the surface of the glass and the cap. Pressure must, however, be exerted if the joint is to be really air-tight. The chosen method depends upon the type of cap used. Two varieties of metal cap are employed. In the case of the *automatic cap* the necessary pressure is obtained by the production of a partial vacuum during sterilisation. This causes the cap to adhere closely to the rubber washer, which is fitted to a projecting rim at the mouth of the container to form an air-tight seal. This type of cap is satisfactory so long as sufficient vacuum exists inside the container. If any flaw appears due to improper fitting of the cap, inadequate sterilisation, gas production internally or loss of vacuum, leakage will occur and the vacuum will be lost. Extremely efficient sterilisation must be carried out when these caps are employed. For this reason they are to be preferred from the hygienic standpoint. The *Phœnix cap* is sealed by means of a rubber washer which is compressed between the edges of the cap and the rim of the container by means of a mechanical contrivance. A metal strip which surrounds the cap grips both the cap and the underside of the rim, holding the closure securely in position. A special closure apparatus is employed to compress the rubber washer and affix the metal collar or strip which retains the cap in position. With this type of cap the development of fermentation and gas production in the container would cause distortion of the lid but would not result in its displacement. From the hygienic point of view, therefore, this type of lid is not so satisfactory.

Sterilisation is either carried out in open vats or in steam retorts. The temperatures employed are naturally not so high as those used in the treatment of canned foods. The usual temperature is in the region of 212° F. Sterilisation is carried out in one process only, the food and its container being heated only once. On this account, it is more difficult to preserve food in glass containers than is the case when cans are employed. When glass packing is undertaken, meticulous cleanliness and care in preparation of the food undergoing treatment must be observed if satisfactory results are to be achieved.

Strained Foods

Large quantities of canned strained foods are now available for infant feeding, fruit and vegetables being treated in this manner. Evidence is available that children fed on such foods benefit considerably. Strained foods also possess therapeutic value, no digestive disturbances being caused in either young or old. The vegetables should be properly selected and efficiently cleansed, trimmed, heat treated and finally strained through fine-meshed screens in the liquid in which they are cooked. They are cooked under high pressure and enclosed in cans so that during the various processes they are protected from atmospheric action or contamination, being always in a closed system or covered with a blanket of steam during treatment. If this were not done the vitamin content would be seriously reduced. Maintenance of correct processing methods in order that the food may retain its utmost nutritive value is therefore of the greatest importance. There appears to be an increasing desire for this type of easily-digested food, present supplies being almost unable to cope with current demands.

Other Methods of Preservation

Apart from the standard methods of food preservation already outlined, all of which are of considerable value in retaining food in satisfactory condition until required for use, numerous other means are employed, mainly applicable to certain types of foodstuffs. Many of these methods, such as *smoking*, *salting*, *sugar preservation*, *fermentation*, *curing* and *pickling*, are of very ancient origin. In addition, various *chemical preservatives* are permitted to be used for a similar purpose. Most of these methods depend to an appreciable extent on the physical and chemical action of one or more of the constituents. Some of these substances exert a bactericidal or fungicidal action by creating conditions unfavourable to the development of micro-organisms and by acting upon such organisms in the form of a poison. Other preservative substances prevent bacterial development, the organisms remaining viable while their metabolic processes are retarded. Chemical preservatives act in this manner when used in the small quantities permitted by legislation. All bacterial life as well as enzymes require moisture for their development and reactions, so that reduction in the moisture content such as occurs in the dehydration process will assist in preserving foodstuffs for a considerable period. What might be termed the *natural preservatives*, such as sugar, salt, vinegar and wood smoke, exert the same preservative action as chemical substances. In *pickling* the pH of the medium exerts a preservative effect, since pathogens do not normally develop in a medium with a pH below 4. Salt in high concentration exerts a plasmolytic effect, while sugar is highly efficient in the preservation of certain types of fruit in the form of jams and marmalades.

When food is preserved by *smoking*, several processes are employed in combination. This method is mainly applicable to meat and fish. A preliminary curing or salting treatment is applied before the substance is allowed to come into contact with the hot smoke. The smoke is produced by burning wood, which should be free from resins or turpentine-producing substances, as these will produce undesirable flavours in the final product. Not only is the moisture content considerably reduced but certain chemical preservatives, such as acetic acid, acetone, methyl alcohol, formaldehyde and a number of creosote compounds, are introduced into the food from the wood, which is burnt in a restricted supply of oxygen. The use of these chemicals individually would be prohibited, but they are allowed to be used collectively in the smoking process. No harmful results have been reported from the ingestion of food containing these chemicals, although the vitamin A and C content is substantially reduced. As the foodstuffs are not fully penetrated by the smoke, no guarantee that all pathogenic or saprophytic organisms will be destroyed can be given.

Salting or curing is carried out by the treatment of the foodstuffs with common salt or with a mixture of salt and saltpetre. When the concentration of salt is in the region of 5 to 8 per cent. an unsuitable medium for the development of spoilage organisms is created. Much higher concentrations, which would render food unpalatable, are required if a germicidal effect is to be produced. Most of the organisms present in food are prevented from multiplying by the use of salt, which also effects a reduction in the moisture content by drawing water from the tissues. Meat, fish, butter, cheese and eggs are preserved by this means, although salt extracts some of the nutritive elements, which are discarded in the resultant liquid. Salting does not render infected or infested foodstuffs safe for consumption, since it does not penetrate the tissues to the extent required for this purpose. A proportion of any pathogenic organisms present may be destroyed by the salt concentration, although this is not always the case.

The employment of *sugaring* as a means of preservation is ordinarily applied to jams, marmalades, jellies and fruit syrups. Sugar solutions of 50 per cent. strength inhibit the development of ordinary spoilage bacteria, although yeasts and moulds are not materially affected. Sugar concentrations of this strength do not destroy bacteria, merely inhibiting their growth. As the substances to be preserved are normally heated during manufacture the micro-organisms present are in any case destroyed, while the sugar prevents the moisture content being available for further bacterial growth. The preservative action of invert sugar is said to be superior to that of beet or cane sugars because of its low moisture content. Glucose and corn sugars are also used as preservatives. Foods preserved by these various types of sugar have rarely been implicated in disease outbreaks.

The *fermentation process* as a means of food preservation depends upon the conversion of soluble sugars to various acids by the action of non-pathogenic micro-organisms. Spoilage and pathogenic organisms are unable to develop in the resultant acid medium produced by the action of acetic and lactic acids. *Vinegar*, a useful preserving agent, is the main product of acetic fermentation ; fermented milks, pickles, butter and cheese result from *lactic fermentations*.

Various *chemical preservatives* have been and still are found in foodstuffs, but only benzoic acid or sulphur dioxide may be used for this purpose at the present time, and then only in certain types of foodstuffs. While other chemical substances may not be harmful in small quantities, their excessive use in food manufacture has resulted in total prohibition. *Sodium benzoate* or *benzoic acid* is used in many countries as a food preservative in small quantities, which if exceeded may result in injury to health. A small quantity is present naturally in prunes. Ill-health has never been associated with its presence in this natural state. Sodium benzoate is not germicidal in neutral solutions but must be present in an acid solution to be effective. The addition of such preservative must be clearly stated on the label.

A number of *sulphites* in the form of sulphurous acid are extensively present in dried fruits. Many of these foodstuffs could not be marketed without their use. When present in excess, however, body changes may result, while gastric disturbances are stated to occur. Free sulphurous acid exerts an irritant effect. In the body the sulphites are converted to sulphates. These are harmless and exert no ill effects. This substance has been used to restore the colour and reduce the odour of meat showing incipient spoilage. When sulphur dioxide is employed as a preservative, the fact must be clearly stated on the label. *Salicylic acid* is a mild chemical preservative which becomes harmful when used in food. It is quite strongly antiseptic and was formerly used as a preservative in jams, fruit juices, syrups and other food products. *Boracic acid* and *borax* were once used extensively in the preservation of butter, cream, margarine, liquid eggs, sausages and certain types of fish. The use of these substances was prohibited by the Ministry of Health in 1928, there being evidence to show that the ingestion of small quantities over a lengthy period exercised a harmful cumulative effect. Considerable opposition to this prohibition came from interested trade sources, but the absence of these substances has not caused any increased food spoilage to occur or any inconvenience to be suffered. These substances can still be used in some countries for the preservation of butter, cream and condensed milk, while they may be present in Chinese liquid eggs.

Formaldehyde, the use of which as a preservative is universally prohibited, is both a deodorant and a powerful germicide. It is highly irritating to the mucous membranes and, in excess, extremely poisonous. It delays the souring of milk and cases have occurred where it has been illegally used for this purpose. *Fluorides* are efficient preservatives but are highly toxic to man, and should not therefore be used in the treatment of any type of foodstuff. *Hydrogen peroxide* is a harmless but ineffective preservative. It undergoes decomposition into oxygen and water, as a result of which any preservative action is lost. Hydrogen peroxide has been used in bottled beverages, and also experimentally to prevent milk souring. *Carbon dioxide* under high pressure exercises a preservative action, a fact made use of in the preparation of aerated waters. Certain *spices*, such as *cloves* or *cinnamon*, possess a useful value in this connection. It should be borne in mind that the addition of chemical preservatives to food simplifies the use of inferior or spoiled materials. Hygienic measures of production are therefore less necessary, while uncleanly methods may be masked. The prohibition of preservatives generally has resulted in improved hygienic standards of production and has encouraged the use of high-grade materials. Excessive quantities should always be looked for, however, foods being chemically examined for this purpose at frequent intervals to ensure that only permitted preserving substances are used and that the legal limits are not being in any way exceeded.

CHAPTER XXVI

CONTROL OF RETAIL FOOD PREMISES

THE importance of food hygiene has assumed much greater significance since the termination of hostilities and has received more attention than was ever before accorded. In the few years immediately prior to the War the conscience of public health authorities and their officers, the consuming public and a proportion of food manufacturers and distributors was being awakened to the need for improved methods in the sale of foodstuffs. This need has now been intensified by current shortages, with the consequent proviso that such food as is available should be preserved in optimum condition until consumed. Much of our food is imported, often at heavy expense. It is heavily subsidised, so that any wastage is a serious loss not only to the consuming public but also to the Treasury. This, of course, is only part of the greater problem which affects public health in its widest sense.

The problem of retail sales is approached from different angles by the food hygienist and the retailer. From the hygienic point of view the efficient control of retail sales is important if public health is no longer to be disorganised by preventable food infections, which take an alarming toll of health and life. The control of retail sales is an urgent duty devolving upon public health officials. Such control is of very great benefit and importance to food consumers in general and, although they do not always realise the fact, to retailers of foodstuffs in particular. Efficient food handling can be carried out in an economical manner. There is no need to complicate or slow up handling processes, make use of elaborate techniques or add to the cost of the article by the application of specific measures of hygiene. Prior to the War, large retail firms had realised that hygiene and efficiency were not competing interests but that they were complementary, one reinforcing the other and combining to ensure a better product. Commercial undertakings are now being made clearly aware of the public consciousness in regard to clean and safe food supplies. With the return of competitive trading when full derationing takes place, there is likely to be a still greater demand for hygienic methods, with an assurance that the quality and cleanliness of the food purchased is above reproach.

Educational measures, which are of vital importance, should aim at emphasising the close relationship which exists between efficiency, hygiene and profit. Less stress might with advantage be laid upon the dangers and incidence of food poisoning, and more emphasis placed upon the increased business likely to ensue when proper hygienic measures are employed. This may appear at first sight a specious if not untenable approach. This, however, is not the case. Fear may help to attain the desired goal, but it is not likely that the improvement obtained will be permanent unless adequate and clearly understood reasons are supplied. Scare headlines in the public press as to the dangers attached to our food supply are of doubtful help. Such an approach is likely to exert a purely transient effect, and until it can be proved to the retailer that sound hygienic practices, and sound hygienic practices alone, are likely to result in increased business, little lasting good is likely to be achieved. An outbreak of food poisoning due to a particular foodstuff affects all retailers in an adverse manner—at least for some little time—and gives that branch of the trade an unenviable reputation amongst the consuming public. Food hygiene is obvious when practised in retail premises, and the public are beginning to respond to attractive salesmanship induced by care in this respect. When one considers the muddled way in which foodstuffs in small general shops are often stored or exposed for sale and the manner in which they are handled, it is not to be wondered that the public is beginning to respond to the efforts expended by the up-to-date tradesman and his assistants.

Wastage of food in shop premises is saved by the practice of hygienic measures. Owing to scientific advances in medical and technical knowledge, the causes of food poisoning and the organisms responsible for such outbreaks can be stated with increasing certainty. This permits demonstration of the manner in which food becomes infected, while the basic principles of protection can be clearly and categorically laid down. These principles should be co-ordinated with the general management principles of food sales as they relate to retail shops.

Quality of the Food

The quality and safety of the food sold in retail premises is of paramount importance. The problem is rendered more difficult by the fact that supplies are drawn from a wide area, so that in the majority of cases quality and soundness are not dependent upon local inspection only but upon supervision in some distant country or town. If such inspection is satisfactory the duty of the local controlling official is likely to be simplified. On the other hand, the local inspector forms the last barrier between the tradesman and the consumer. He is most intimately concerned with contamination introduced during local storage, preparation or display, with any spoilage which may occur and with faulty methods of handling. Again, as the causes of food poisoning are most frequently local in origin and are often due to faulty treatment in the retail premises, the responsibility of the local controlling official is greatly increased in that his methods of supervision should be such as will preclude danger arising from such sources of contamination.

Certain considerations affecting the quality of food exposed for sale are intimately connected one with the other. The *appearance of the food* is of major importance. Any abnormality in appearance, texture, colour or odour must be the subject of careful investigation, as should obvious contamination with dirt or other obnoxious materials. Suspected adulteration must also be investigated. Visual inspection is often sufficient to determine whether or not food is unfit for use. Such food can be condemned forthwith. In borderline cases, a bacteriological and/or chemical examination may be necessary before adequate judgment can be made. Laboratory examinations are often necessary before visual judgment can be confirmed. Such doubtful food should be withheld from sale until further information is available. Action on these lines protects the retail purveyor, the consumers and the official concerned. Food should never be condemned as unfit on doubtful evidence only. In this connection it should always be borne in mind that appearances may be deceptive. As an instance, infection with food-poisoning organisms is not detectable with organoleptic tests ; while certain cheeses and game may appear unwholesome and yet be fit for consumption. It is important, therefore, that a full history of the food should be obtained.

Samples should be taken for laboratory examination in any case of doubt, the remainder of the suspected food being retained under refrigerated conditions until further evidence as to its fitness is available.

The *source of supply* should always be investigated. This is of particular significance, as the food may not be wholesome on arrival at the retail premises, having been spoiled or contaminated in transit. Inquiries should be made as to whether or not the food has been inspected at the point of production. Such inspection is no guarantee of soundness on arrival at its final destination, however, as the *age of the food* may have caused it to deteriorate, particularly if stored under unsuitable conditions. Inspection of the delivery notes or invoices may assist in determining the age of the foodstuffs and may also supply valuable information regarding its history. Certain foods call for condemnation or detention even when sound. Instances are out-of-season fish, immature shell-fish, poisonous fungi sold as or mixed with mushrooms, greenish potatoes, which contain solanin ; swollen, bulging or imperfect canned goods ; contaminated sweets, bread or confectionery ; obviously undercooked meats, unpasteurised ice-cream and foods accidentally contaminated by refrigerator leaks or with waste water from defective pipes.

Condition of Premises

If food is to be prepared and handled in a thoroughly hygienic manner the general condition of the premises assumes considerable importance. At the present time all new retail food premises have to be licensed by the Ministry of Food. Under pre-War conditions any person was allowed to open a food store without official permission. Even now, when licences are required, liaison between the local food office and the public health authority may be poor. Indeed it is by no means unknown for food premises to be operating for some time before the local officials responsible for their supervision are aware of the fact. Before any retail food shop is opened or if any change of ownership is proposed, the local health authority should be informed by the person or persons responsible with a view to ensuring that the premises are suitable in every respect. Any necessary alterations could then be made to conform to modern requirements. Existing legislation requires amendment to provide for the registration of both food premises *and* their occupiers. This is a matter towards which official attention should be directed without delay.

The *floors* of food premises should be smooth and constructed of material capable of ready cleansing. Boarded floors of softwood, which are so often found, should not be approved. Such floors collect dust which is readily disturbed by the movements of customers. They also absorb grease and moisture unless overlaid with heavy linoleum, sealed to the wood. Tiles, terrazzo or hardwood form suitable flooring materials. All angles between floors and walls should be rounded or coved. Floors should be kept free from dust and dirt and should be cleansed daily. The general appearance and hygienic condition of the premises is closely related to the construction of the *walls and ceilings*. A smooth painted surface, finished in light-coloured oil paint, is to be recommended. Glazed-tile walls are sometimes provided. These are expensive and not essential. Wooden or plasterboard surfaces should be discouraged. Such materials warp and are not impervious to moisture or dirt, and often provide harbourage for insects or other vermin. Any equipment such as *slicing machines* or *scales* should be fixed away from wall surfaces. Periodic repainting of walls is necessary. All crevices and cracks should be made good during this operation to prevent the possibility of infestation.

Door and window openings should be screened, particularly during hot weather, to prevent the entrance of flies. Such door or window screens should be stoutly constructed to withstand continued use, otherwise they may warp or be damaged, when flies will obtain entrance round the frames. Fly-proof doors should open outwards and be self-closing. Doors and windows, which should always be close-fitting, should both be screened with sixteen-mesh metal. *Fans* may be installed near door and window openings to act as fly repellants. Good *lighting* is important. This lessens fatigue, increases efficiency and prevents accidents, while greater cleanliness is more likely to follow. The employment of fluorescent lighting has made rapid advances in shop premises and is superseding the older types of fixtures, particularly in the larger stores and better-class shops. For all premises adequate lighting is particularly important as an aid to cleanliness. The adequacy of the lighting provided should always be measured by means of a light-meter, which should be available to all supervising officials. A minimum of 10 foot-candles of light should be provided in all shop premises. This may have to be increased at certain points. Good lighting is also essential in toilets and in cloakrooms. Four foot-candles will normally suffice in warehouses and store-rooms. Measurements in relation to lighting should be taken at a height of 30 inches from floor level. Natural lighting is also important. Windows should be kept clean to admit the maximum available daylight. The rear portions of the shop premises proper are often difficult to illuminate naturally owing to the depth from front to back. The window area should be equivalent to 10 per cent. of the floor area. The *uniform distribution of natural light* is most important, while the proper location and spacing of windows must not be overlooked. Adequate *ventilation* should be provided. Any definition of adequacy must be left to the controlling official. It will be sufficient to state that the methods employed should be such as will render the premises airy and sweet-smelling. Stale air should be rapidly removed as frequently as is required.

A safe, adequate *water supply* must be provided in all food premises. Retail food shops are no exception to this rule. This is particularly the case with butchers', fishmongers' and grocers' shops, where utensils and other apparatus must be regularly washed. Where a mains supply is available in a town no difficulty is likely to arise. In country districts, however, even mains supplies are not always above suspicion. If no mains supply is available, as is often the case, difficulties are likely to arise in regard to purity. Some form of chlorination on the premises will then be indicated. Some method of *water-heating* is also necessary, as slabs, counters and utensils require frequent washing. If electricity is available, an electrically-operated water heater should be installed, although gas heaters are also suitable and provide ample quantities of hot water. When gas is employed, the fumes should always be removed into the open air by means of a suitable flue. The size of the heater will, of course, vary according to the quantity of water required, which in turn depends upon the type of food business carried on. In certain types of premises a coal- or oil-fired boiler may be installed to provide a constant supply of hot water. Whichever type is provided, hot water in adequate quantities should be available when required.

Suitable *cloak-room accommodation* is important although too often overlooked. The sole provisions made for this purpose frequently consists of a small compartment provided with a w.c. pan and a wash-basin or sink. The general impression is often one of disuse, while the w.c. pan may be, and often is, in a filthy condition. Cloak-room accommodation should always include adequate w.c. and hand-washing accommodation, together with adequate storage for clothing, points which are often overlooked in the design of the average shop premises. Separate *w.c. accommodation* should be provided for the sexes, and should not open directly into any room where food or drink is handled or stored. The intervening space, which must be properly ventilated, should be of sufficient size to ensure that both doors, which should be of the self-closing type, cannot be opened by one person at the same time. This space can be utilised for the installation of lavatory basins. This compartment and also the w.c.s should be adequately lighted and should be ventilated into the open air. They should be maintained in a satisfactory condition at all times. In every toilet room provided on food premises a conspicuous sign or signs should be posted directing attention to the need for washing the hands before the employee returns to work. This instruction should preferably be stencilled on the wall surface, as other types of notices are readily damaged or destroyed.

The provision of adequate *hand-washing facilities* is of paramount importance in all premises where food and drink are sold. Employees cannot be expected to develop a consistent habit of cleanliness unless adequate facilities are provided for their use. Hot and cold running water, soap and an adequate supply of clean towels should always be available. Mixing taps should be fitted, operation by means of foot pedals being desirable. As already indicated, the necessary number of lavatory basins may be provided in the vestibule leading to the w.c.s. *Towels* may be of the continuous pull-down type or may be separate units, the former being preferable. Owners should supervise their use to ensure that sufficient towelling is available on the roller for further use. Small hand towels are apt to be thrown about and rapidly become soiled, while if sufficient length of clean continuous towelling for each user is maintained little difficulty is likely to ensue. Paper towels may also be provided, and are increasing in popularity. Provision for *clothes storage* during working hours should be made as an integral part of cloak-room accommodation. Outdoor clothing is too often found hanging in close proximity to foodstuffs. Containers for soiled overalls, aprons and caps should be available.

One of the most commonly neglected problems in relation to food premises is the provision made for the *storage of refuse* until it is removed for disposal. Galvanised metal bins should always be provided for this purpose and should be fitted with tightly-closing covers. In far too many instances old boxes, barrels or crates are pressed into service as refuse containers. Even when metal bins are provided they are frequently battered, misshapen or leaking, while the covers may be missing. It is also exceptional to find that bins are washed out regularly and kept in a really clean condition. This is often due to the fact that no space is available at the rear of the premises for this work to be done. If at all possible, sufficient space at the rear of the premises should be provided for this purpose, while bins should be stored under cover. The lids should preferably be secured to the containers by means of a short length of chain. The proper storage of refuse at food shops is important if flies, odours and vermin are to be adequately controlled. Efficient disposal of liquid waste matters is, of course, essential.

Prevention of Food Contamination

Sound, wholesome food may be contaminated in a variety of ways. Many of the defects which exist in the methods now practised are obvious to the hygienist. *Open displays of food* are to be seen much too frequently in food shops, due mainly to lack of thought, indifference or even carelessness. There is no adequate reason why foodstuffs should not be protected from persons coughing, sneezing or otherwise subjecting the food to droplet contamination, even allowing for present-day shortages in the right type of equipment. Experiment has shown that large droplets can travel a distance of 12 feet from a person's mouth or nose during sneezing, the average distance being approximately 3 feet. During sneezing most of the droplets are expelled from the mouth, bacteria being readily disseminated over foodstuffs in this way. Cooked meats, salads, sweets, cheese, confectionery and innumerable other articles eaten as purchased without further cooking are particularly vulnerable to this type of contamination. The same foods may also be open to handling by customers and to contamination by dust. Goods of this type should be displayed under glass, in some type of transparent case or, preferably, in a refrigerated display cabinet. The covering of foodstuffs with cellophane or waxed paper gives no guarantee of permanent protection owing to the ease with which the covering can be accidentally displaced. It should also be borne in mind that flies can readily obtain access to food so covered. Some food retailers are alive to the problems involved and suitably protect such foods. Even when foods are normally cooked after purchase some form of protection should always be considered necessary. Far too many retailers still display their goods without any type of protection. Legal powers to prevent this practice should be available to controlling officials and should be exercised, due regard being, of course, given to prevailing shortages.

Refrigeration is extremely important in all retail food premises as a means of preserving food from bacterial and enzymic action and metabolic changes. The use of refrigerated display cabinets ensures that food can be preserved and protected from contamination at the same time. The value of this means of food preservation is not sufficiently appreciated by food retailers, except by butchers and fishmongers. Its usefulness cannot be overemphasised, as lack of refrigeration or failure to use such facilities in the proper manner has been, and still is, a potent contributory factor in the causation of outbreaks of food poisoning. Food should be retained in sound and palatable condition, and also free from bacterial growth which leads to spoilage. For this very good reason the need for suitable means of storing foods at low temperatures must be continually emphasised. In those premises where refrigeration is provided the method has become so familiar that it is often taken for granted. Inefficiency may therefore result by occasion of lack of care, while the process may fail to accomplish its intended purpose due to the employment of unsuitable temperatures. Where refrigerators are installed, temperatures should be checked as to their efficiency for a particular purpose by the controlling official. In this way the tradesman may be suitably impressed with the importance of the method, while a check is valuable from the public health point of view.

Foods will often be found stored at temperatures too high to retain them in suitable condition. The accommodation provided for the cold storage of foodstuffs should be entirely adequate. Much more extensive use might profitably be made of refrigerated display cabinets in which food can be placed in full view of the customer. The extent of refrigerated space required will, of course, depend upon the type of food premises concerned and upon the quantity of food to be stored. Refrigerators should be properly used when installed and they should always be maintained in a thoroughly clean condition. No food should be placed on top of the cooling units or in the drip trays below such units, otherwise air circulation will be restricted and the units become frosted. The metal shelves should be left uncovered so that air can readily circulate, to prevent sweating of the products. Fresh meat should be hung in such a way as to ensure free circulation of cold air round all sides. When hung from hooks, the hooks should be movable so that proper spacing can be arranged. Piling portions of food together should be avoided. If this precaution is neglected the cold air may be prevented from reaching all portions of the food as rapidly as is required. Similarly, layers of sliced meat should not exceed 4 inches in depth.

Regular cleansing of refrigerators with a satisfactory detergent is essential. After cleansing, the interior should be wiped down with a cloth which has been wrung out in a suitable hypochlorite solution. The mechanical condition of the refrigerator should be properly maintained. Fittings and movable parts should be frequently inspected. The fitting of doors should be carefully checked to ensure tightness at all times. Food hygienists responsible for the supervision of retail food premises should pay very great attention to refrigeration as a means of food preservation, by educating the retailer as to the need for such installations and by ensuring that highly-efficient operating standards are maintained at all times. The advent of quick-frozen foods has necessitated the use of refrigerated display cabinets. This is a step which may have valuable repercussions in rendering retailers more refrigerator-conscious in respect of other foodstuffs.

The protection of food against the depredations of *insects* is of considerable importance. Cooked meats, bacon, butter and other articles are too frequently allowed to remain on shop counters over-night and during week-ends, open to pollution by flies, cockroaches, ants or other insects. Of these insects, flies are most commonly implicated in the infection of foodstuffs. Every effort should be made to prevent their depredations. The harm which can be done by flies is too well known to require further emphasis. While the destruction of individual flies is important, the elimination of conditions conducive to breeding and, equally, the eradication of conditions likely to attract flies are an even greater necessity in relation to retail food premises. The vicinity of the premises should be kept free from refuse. Waste food, soiled wrapping papers, empty bottles, cans and other types of waste should be stored under cover, suitable metal refuse bins with tight-fitting covers being provided for this purpose. Fly-sprays of various types are useful, although care must be exercised in their employment in order to ensure that unprotected food is not contaminated. Fly-papers impregnated with D.D.T. provide a useful deterrent. Greater attention to the breeding and feeding places of flies is, however, more likely to yield satisfactory results. Fly-repellent fans might be installed, while openings should be screened with suitable wire-mesh screens. The use of a 5 per cent. D.D.T. solution combined with a " knock-down " substance such as pyrethrum will assist in preventing fly depredations.

Wherever food is stored *cockroaches* are likely to be found, if suitable care is not taken. Cockroaches not only constitute a serious nuisance but impart an unpleasant odour to any food with which they come into contact, and also to premises. They are further known to be the mechanical means of disseminating pathogenic organisms to food touched during their peregrinations. The nocturnal habits of cockroaches presents an additional problem. They obtain entrance to premises from packing cases, straw or by migration from one building to another, and will feed on any type of human food. Scrupulous cleanliness is important in their control, removal of food scraps at the end of each day's business and thorough cleansing of greasy knives and other utensils being of the utmost importance. It is also essential that food be properly stored. If adequate hygienic measures are practised little difficulty is likely to be experienced with this type of infestation. Cockroach powders and powders containing 5 to 10 per cent. of D.D.T. are efficacious if properly used. Many powders contain sodium fluoride, so that great care in their use is necessary, this substance being extremely poisonous. It should not be sprinkled in any place where it is likely to come into contact with foodstuffs. The use of hydrocyanic acid gas will clear the premises, but again extreme care is necessary in the employment of this substance ; where the use of this gas is favoured expert advice should always be sought. *Ants* are frequently attracted by food in such numbers as to become a serious nuisance. For this reason food supplies should be inaccessible to ants. Slow-acting poisons are used successfully for their destruction. D.D.T. as a 5 per cent. spray or as a 10 per cent. dust may be employed.

Vermin in the form of *rats and mice* are frequently found in food premises. suitable control measures are essential in order to prevent their depredations. If unchecked these are likely to cause serious wastage of food. Rats are a further menace to public health, as they may contaminate food with pathogenic organisms or with intestinal parasites. They may also act as carriers of the causative agent of infectious jaundice. Food-poisoning organisms are excreted in their fæces. The part which rats and mice can play in the transmission of Salmonella food poisoning has already been mentioned (see Chapter IV). Buildings should invariably be rat-proof. This point should never be overlooked after any infestation has been discovered. All openings through which rats may gain entrance should be sealed before extermination measures are employed. Food should be placed out of reach ; refuse should be stored in covered bins. Poisoning, trapping or fumigation may be employed in rodent destruction. Care must be exercised if a dangerous poison is used for this purpose. Generally speaking, unhygienic practices are the cause of rat infestations just as they are in the case of insect pests. Food in retail premises should be exhibited and stored so that *cats and dogs* cannot contaminate it. Many food shops keep a cat to deal with rats or mice. Provided care is exercised, no pertinent objection can be raised to this practice. When the premises are closed, food should be placed in an inaccessible position so that the animals cannot obtain access to it. Dogs should be excluded from all food shops for æsthetic reasons and, more significantly, because of the contamination which may arise in food and food containers with which they come into contact. The role of cats and dogs in the transmission of Salmonella infections has already received attention in Chapter IV.

Food may become contaminated by *chemical substances* with which it comes into contact. The dangers arising from contamination by poisons used in the destruction of insects and vermin have already been mentioned above, and it cannot be too often emphasised that the greatest care is necessary in the handling and storage of such substances. Food should not be placed in or on *zinc-coated vessels*, as acid food will dissolve the zinc. Potato salad containing vinegar in the mayonnaise with which it is mixed and foods containing fruit acids will dissolve an appreciable amount of zinc. Cheap trays and containers of grey enamel containing *antimony*, which is also dissolved by acid foods, are often found. *Enamelware* should never be used in food stores and should be replaced where necessary by vessels of stainless steel or aluminium. *Cadmium*, which is used for plating utensils and containers, can also be dissolved after contact with acid substances and can cause illness. When ailments due to the consumption of food are reported, the probability of some type of chemical poisoning being responsible should always be borne in mind.

A certain degree of *miscellaneous contamination* may occur, due to unhygienic practices among the personnel and other causes. If not carried out in a satisfactory manner, floor sweeping is likely to cause dust to be deposited on unprotected foodstuffs. A sweeping compound should always be employed to damp the dust and prevent it rising. Careless deposition of dirty containers, dishes, etc., on counters and carving slabs can contaminate food to a serious degree. Unclean knives and slicing machines are also implicated, while the use of soiled cloths for wiping dishes, counters and other articles with which food may come into contact represents another source of danger. All potential sources of food contamination should be frequently pointed out to the food store proprietor and his staff during inspectorial visits.

Personnel

However suitable shop premises may be and whatever the care taken to protect foodstuffs from contamination, the efforts expended in this direction will be largely nullified unless the personnel play their part. Many shop assistants have poor educational backgrounds in spite of the facilities for education now available. For this reason a common-sense down-to-earth approach, with practical demonstrations, is often necessary if the important principles of personal hygiene are to be properly understood. Highly technical explanations are of little use. Instructions and suggestions should be couched in simple language. It has never been possible to state with certainty how much infection has been caused through carelessness and the unhygienic handling of food, allowing for the fact that food-poisoning outbreaks do serve to indicate the possible dangers. It is thus sometimes difficult to convince the food handler that continuous care and vigilance are required. Inspections of retail premises in the past have mainly concentrated attention upon visible defects. Far too little attention has been paid to the personal habits of those responsible for the serving of food. The average food-shop assistant normally starts out as an errand boy; some, indeed, have been virtually pitchforked into the food business because of economic circumstances. It should always be remembered that young women and girls engaged in the food industry are very often employed in what is to them a dead-end occupation, and seem to care little or nothing for the principles involved.

Personal hygiene is not a new science. The medical profession has been preaching its well-established principles for many years, often with singularly meagre success. The application of such principles to retail food sales is a simple matter, but their *continuous* application is an entirely different proposition. A proportion of assistants appear to be totally incapable of handling food in an adequate manner, due either to background or to temperament. Added to this is the fact that the personnel may change rapidly. Employment is not always stable, even in normal times, while the assistants are usually quite untrained in correct methods of handling food. During rush periods carelessness is particularly liable to be shown. These factors all influence the problem and demand most careful consideration.

Attendance at courses of instruction in the proper methods of handling food should be compulsory for all food handlers in retail shops. Although most trades require some evidence of competency, it is disturbing to find that the retail food trade is still prepared to accept any person willing to do the work. This is a significant fact, too often forgotten. It is to be hoped that the higher wages now being offered will attract a better type of recruit, although this hope may, unfortunately, be mitigated by the lack of suitable promotion prospects, due to the fluctuating nature of the retail food trade. Members of the trade realise the deficiencies of the present system. It is an unhappy fact that voluntary methods do not at present appear to be making any appreciable headway so far as the education of assistants in the practice of improved methods is concerned. This, of course, should not be allowed to mitigate against the praiseworthy efforts being made by a number of authorities and organisations to effect a change for the better.

One of the prime desiderata in any person handling food is that he or she should have clean hands at all times. Hands should be washed before work is commenced, every time the w.c. is used, and as often as may be necessary at other times. This is particularly important if the hands become contaminated by discharges from the nose, mouth or intestines. Finger-nails should be kept trimmed and free from dirt at all times. If adequate supplies of hot water, soap and towels are made available by the proprietor, it is natural to expect the employees to make the fullest possible use of such facilities. If adequate supplies of running water are not available, portable wash-basins should be provided. Women assistants should be provided with suitable head coverings to prevent hairs or scurf obtaining entrance to foodstuffs ; all food handlers should be required to wear clean white overalls, which should be frequently changed and laundered. The normal outdoor clothing should always be covered in the case of persons serving food, since it may have become contaminated either in the home or during the journey to work. The health of assistants should not be overlooked. Persons suffering from colds, sore throats, diarrhœa, skin affections or, indeed, any type of communicable illness should not be allowed to handle food. There is no excuse for sick persons continuing at work in these days of standing wages and National Health Insurance. Food-shop proprietors should ensure that sick persons reporting for work are sent home, and that they remain there until recovery.

The general *habits* of the shop assistant are also important, as are the methods employed in serving food. Coughing and sneezing in the vicinity of food is a common practice. Failure to wash the hands after using the w.c., licking the fingers after serving greasy foods, picking at spots on the face or in the nose, biting the finger-nails, licking the fingers or the knife to taste food, wiping the hands on the not-always-too-clean apron, wiping knives on the apron and similar practices are often observed in food shops, and cannot readily be prevented by legislation. Education is much more likely to achieve improvements in this field, although constant effort will certainly be required. This is also the case when methods of serving are considered. It is quite common to see bread and confectionery, sliced meats, bacon and even butter and margarine touched by hand during service and weighing. The prime responsibility lies with the proprietor or manager of the premises. If by example and precept he leads the team in the right direction, his employees are much more likely to react to education and advice. If he is indifferent to any consideration but the profit likely to accrue from sales, and fails to realise that his income might be considerably enhanced by public realisation that his establishment is hygienically run, success can never be expected.

Food Hygiene Guilds

Food hygiene guilds are intimately bound up with retail food establishments. Consideration might therefore be given to their constitution and activities at this point. Following the termination of hostilities in 1945, public health authorities, realising the difficulties under which they were working in relation to food hygiene, became more intimately interested in the methods employed in the manufacture, handling and distribution of foodstuffs. Prime mover in the search for a new method of approach was the Borough of Guildford. In 1946 an investigation was carried out by the sanitary inspectors in the borough into the methods employed in dealing with all types of food, from the raw materials until the foodstuff arrived at the consumers' tables. A careful survey of all food premises in the borough was undertaken. From the report subsequently prepared it was clear that in a number of instances the standard of hygiene, both in regard to premises and personnel, left something to be desired, although in the majority of cases the reports stated that the standards could be considered reasonably satisfactory. As a result of the final report, to which due consideration was given by the Guildford Public Health Committee, a special sub-committee was appointed to consider possible steps which might be taken to bring about improvement. Several meetings were held between members of this sub-committee and representatives of the food trades' organisations. Arising out of the joint discussions, it was decided to form what was termed the Guildford Hygienic Food Traders' Guild, an advisory committee being set up to operate the scheme. This committee was composed of a number of members of the borough council, together with trade members representing various food trades. A representative was also co-opted from the trade union covering the interests of the employees.

The Advisory Committee decided that there should be no charge for membership of the Guild, but that membership should involve strict observance of the codes of practice appertaining to the trades carried on, and that any failure to observe such standards would involve the privilege of membership being withdrawn. Separate codes of practice were prepared for the various food trades concerned. These were based entirely on the legal requirements of the Food and Drugs Act, 1938, to which were added other desirable points applicable to particular trades and agreed to by a special sub-committee of the Advisory Committee. These codes of practice were given detailed examination by the sub-committee and were finally approved. Copies, together with an outline of the proposed scheme, were sent to each food trader, who also received an invitation to join the Guild.

Not only the owners of food businesses but also their employees were approved as eligible to join the Guild. On receipt of the application to participate, the applicant was informed, following an inspection of his premises, whether these complied fully with the codes of practice ; or, alternatively, to what extent the premises or the hygienic standards fell short of those accepted as requisite for the purpose. When considered satisfactory, the applications were submitted for consideration by the Advisory Committee, whose decision in every case was final.

The proposal, when published, aroused considerable interest in the town, and a reasonably satisfactory measure of support was received by the Committee. Approximately 37 per cent. of those traders who applied for membership of the Guild were accepted as being satisfactory in respect of premises and methods. Most of the remaining applications had to be deferred until necessary improvements were brought about either in regard to premises or methods. Only some 21 per cent. of the local food traders appeared uninterested in the scheme at its inception. Apart from local interest, however, details of the Guildford Guild received wide publicity. Other local authorities realised the benefits of the campaign. Aldershot prepared and adopted a comparable scheme in 1948. This followed very closely upon the Guildford pattern, except that the codes of practice were combined into a suitable booklet instead of a separate code being issued for each food trade. Badges were also provided for issue to employee members of the Guild. Willesden soon followed, although in this case no preliminary survey of food premises seems to have been made. Codes of practice based upon those compiled by Guildford were drafted and adopted. The borough council gave its full support, although it was expressly emphasised that the Committee was a body entirely independent of the borough council. It was agreed that certificates should be issued to traders complying with the codes as ascertained from a report submitted by the sanitary inspector in whose area the premises were situated. The food traders who were approved as members of the Guild were asked to display these certificates in their premises. An initial registration fee of 10*s.* 6*d.* was payable by each applicant.

From the initiative first displayed by Guildford has grown a movement which has resulted, *inter alia*, in the rapid spread of food hygiene consciousness throughout the country. The formation of hygienic food traders' guilds has now received the official approval of the Minister of Food, and has thus received an impetus which has resulted in still more guilds of one type or another being formed. Many local authorities have set up food hygiene committees, whose functions might be summarised as including :—

(1) The determination of applicable codes of practice.

(2) Examination of applications from food traders and their employees for membership.

(3) The granting of certificates and, where considered desirable, badges to applicants whose applications are deemed satisfactory after inspection and report by a sanitary inspector.

(4) Consideration of such matters as may arise from time to time in relation to such a scheme.

Specimens of the Guildford Codes of Practice will be found set out in Appendix 1, on pp. 457 to 476.

A Food Hygiene Section has been set up by the Ministry of Food to deal with problems of food supply and handling. Another function of this section is to co-ordinate the efforts made by local authorities, manufacturers and retailers in relation to food hygiene generally. More recently still, Model Byelaws with reference to food handling have been published (see Appendix 2, pp. 477 to 481). When adopted by a local authority, these bye-laws, which are permissive, can be used to provide more adequate control over food premises of all types, together with the methods employed therein. Every activity of the food trader can now be more stringently controlled. In spite of these advances much work remains to be done, particularly in rural communities, where food is not always produced or handled under the best conditions. Further, time must obviously elapse before the ultimate aim of complete hygienic food handling is achieved in relation to retail food establishments.

CHAPTER XXVII

KITCHEN HYGIENE

DURING and subsequent to the War, a quite substantial increase has occurred in the quantity of food prepared and eaten in restaurants, canteens and the like. This development has been largely brought about by reason of food rationing requirements and food shortages, together with the need, particularly in factories and other workplaces, of saving the time of employees in searching for meals. This latter factor has led to the compulsory establishment of canteens in factories employing more than 250 persons. In addition, the school meals service has made rapid advances, while municipalities have been encouraged—not always wisely—to open restaurants for the sale of cheap but nourishing meals. It may, indeed, be stated that the catering trade, with all its ramifications, has never been so prosperous, the provision of cooked meals and snacks of various kinds now ranking as one of the most flourishing undertakings in the country. The habit of eating out is likely to continue, provided caterers conduct their business with suitable emphasis on hygiene. If this is not so, the increased business obtained is likely to decline, since the public is rapidly becoming more conscious of the need for applying adequate measures of food hygiene. Not only have food shortages been one of the prime causes of the increased number of meals sold in the various types of catering establishments ; certain other advantages accrue from the practice of dining out. Food economies are possible when people are fed in bulk, while fuel and labour are also more profitably and economically utilised. Increased social benefits are also available, while it has been possible to provide a more balanced diet than might otherwise be obtained. In this connection, the provision of meals to school children has resulted in marked benefit to their health. Thus, in spite of its obvious disadvantages, communal feeding has a valuable contribution to offer, always provided the food consumed is properly handled and prepared.

The growth of communal feeding has focussed attention upon many points not formerly accorded the serious consideration they deserved. Particular attention has been directed to the handling, storage and preparation of food in all premises where meals are sold. Due emphasis has also been placed upon premises, personnel, and methods used in food preparation. Notwithstanding certain deficiencies in the system, all of which are obvious, propaganda has been used in an unnecessary alarmist fashion, with unfortunate results. Admittedly, risk to health does exist where food is not handled and prepared in a proper manner. It must be emphasised, however, that there has been an unhappy tendency to over-estimate the results likely to accrue from the consumption of communal meals. As an instance, far too much is made of mortality figures to prove that communal feeding may be dangerous. It has more than once been shown that such statistics have erroneously included deaths from other diseases which would have occurred in any event, and which had little if anything to do with the consumption of infected food. The employment of tactics of this description will not assist in achieving those worth-while improvements which are so vitally necessary. The true position has often been obscured, and the catering trade, whose co-operation is so urgently required, has tended to view with suspicion figures of this calibre. It need scarcely be emphasised that this is *not* the way to encourage willing co-operation.

There can be no doubt, however, that all concerned with the improvement of public health generally are well aware that there is an ever-present risk of food-poisoning outbreaks if scrupulous care is not exercised in the handling of food. It is towards the prevention of such risks, wherever possible, that the attention of sanitarians should be directed, recognising the risk involved when kitchen hygiene is neglected. Difficulties in obtaining speedy improvement undoubtedly exist. Alterations to premises are often delayed, due to shortages of labour and materials. Education of catering workers has been rendered difficult owing to the scarcity of soap, towels and cleansing materials, while proprietors of catering establishments are faced with labour problems which have substantially increased the difficulties under which they normally work. In spite of this, there does appear to be an increasing awareness on the part of those responsible for the provision of meals, that improvements in method and technique are urgently necessary. This is particularly the case with a substantial proportion of the large catering firms. Their example might profitably be followed by those operating on a smaller scale. The problem of the small café, snack bar, boarding-house or small hotel is not always capable of a simple solution for a variety of reasons, which will be considered later. In spite of the many improvements which have taken place, it cannot be said that the standards of personal or commercial hygiene are satisfactory in every respect.

So much is this so that in November, 1948, a Catering Trade Working Party was formed by the Minister of Food to consider and report on the precautions considered practicable and desirable in order to improve the hygienic conditions in catering establishments. Their report, issued in February, 1951, is of vital interest to all concerned with the provision and sale of prepared meals, and the public health factors involved. The main recommendations of the Working Party will be found in Appendix 3, pp. 489 to 491. Legislation, which might be improved, is certainly available, but something more is required if lasting success is to be achieved. It is vitally necessary to secure the co-operation of the trade and, more especially, to create interest in improved methods amongst those responsible for handling and preparing food. Legal action can always be employed to deal with the negligent or unwilling minority ; the problem is more acute in respect of those—and they are many—who are both able and willing to learn.

Types of Catering Premises

Each catering establishment presents inherent problems peculiarly its own. These must be understood, if success is to be won. Catering premises may be classified as follows :

(1) Hotels.
(2) Boarding-houses.
(3) Cafés, restaurants and snack bars.
(4) Roadside and transport cafés.
(5) Railway buffets.
(6) Public-houses.
(7) Municipal (civic) restaurants.
(8) School canteens.
(9) Industrial canteens.

(1) *Hotels.* Hotels vary both in size and type ; conditions found therein are as varied as the premises themselves. While many of the larger hotels are reasonably satisfactory, this fact should not be taken as being generally applicable. Similarly, smaller hotels may be either satisfactory or the reverse. No general rule can be applied to hotels, owing to the type of premises and the quality of the management exercised. It will quite often be found that the space available for the work carried on is totally inadequate. This has often caused equipment to be badly sited, so that satisfactory measures of cleansing are rendered extremely difficult, if not virtually impossible. Kitchen ventilation may be extremely poor, while it may not be possible for fumes and steam from cooking operations to escape readily into the open air. Failure to arrange for the rapid escape of fumes and steam plays havoc with the condition of walls and ceilings, so that there is often need for frequent cleansing and redecoration, a need which is often neglected owing to the difficulty in carrying out this work without disrupting the life of the hotel. A marked lack of accommodation for the personal ablutions of the staff is frequently found, while many kitchens are infested with rodents or various types of insect pests.

(2) *Boarding-houses.* Conditions found in boarding-house kitchens are frequently worse than those which exist in hotels. The *bona fide* establishment can be readily supervised, but many premises of this type exist which carry on the trade of catering for visitors as a side-line and do not advertise the fact that such facilities are provided. Due to an understandable desire to reap maximum financial benefit during the short season available, seaside boarding-house or private hotel proprietors and their staffs quite often use the kitchen as living quarters. This is highly unsatisfactory from the point of view of food preparation and storage, since it is almost certain to lead to contamination. In a substantial number of cases the only food-storage facilities available consist of a dark room in the basement, which is entirely inadequate. Refrigeration space for the storage of perishable goods and " left-overs " may not be available. Cooking and food preparation are quite often carried out in basement rooms, where ventilation is rarely satisfactory and where facilities for the disposal of steam and fumes are totally inadequate. Distempered walls and ceilings quickly flake in such a steam-laden atmosphere. When the walls are covered with paper, as is so often the case, the material quickly falls away and leaves a bare, porous-plaster surface in full view. This surface cannot be readily cleansed. Floors are frequently covered with linoleum and littered with old mats. Such coverings are quite unsuitable. In other cases bare boards, often rough and porous, are left uncovered. There is frequently a lamentable absence of adequate washing facilities for the kitchen staff other than the kitchen sink, where food is prepared and crockery washed. The same sink is often used for domestic laundry work. As in all food-preparing premises, vermin infestation may be present, while domestic animals are frequently allowed to sleep in the kitchen over-night.

(3) *Cafés, Restaurants and Snack Bars.* The greatest variation in prevailing conditions is likely to be observed when dealing with cafés, restaurants and snack bars. Large restaurants, which have been designed for the purpose and which are efficiently supervised, are usually satisfactory. This is not always the case, however, especially in seaside and popular tourist areas. When one comes to consider the smaller type of café and restaurant, including snack bars, the standards leave still more to be desired. The basic

demand for meals by visitors may result in the employment of unsatisfactory rooms, some of which may have been converted for use as kitchen premises. Premises of this type are often totally inadequate for the volume of business carried on, while the kitchen equipment may be so badly arranged that adequate cleansing is virtually impossible. As with other types of premises already mentioned, ventilation is often inadequate and incapable of conveying steam and fumes into the open air. Food-storage accommodation and storage for waste materials are frequently unsuitable, while lighting in the kitchens may be insufficient. Facilities for the cleansing and sterilisation of equipment, crockery and cutlery are often inadequate ; generally there is no provision for personal ablutions. A close inspection behind food service counters often reveals unsatisfactory conditions which are not visible to the patrons. Prepared food exposed for sale on service counters should always be protected from contamination by means of glass shields. This is not always the case in small establishments.

In relation to cafés, restaurants and snack bars, and, indeed, when dealing with any type of catering establishment, the visible evidence of dirt and carelessness in that portion of the premises open to the public should lead one to expect more serious defects elsewhere. A slovenly waitress will almost certainly mean a careless cook ; grubby table-cloths, dirty cutlery and cracked or chipped crockery indicate what one can look for in the kitchen behind. Dust in the restaurant will scarcely be absent from the vital food-preparing section of the establishment. These are the danger signals which should first be observed. Their testimony, mute but undeniable, should never be disregarded.

(4) *Roadside and Transport Cafés.* The expansion of long-distance road transport during the last twenty years, particularly on certain specified main-road routes, has led to the opening of a large number of premises supplying meals to lorry crews and other road users. While such meals are generally reasonable in cost and physically satisfying, the premises in which they are prepared and the conditions under which the food is handled quite frequently leave much to be desired. Such premises are often badly sited, particularly in country districts, where water supplies and drainage, electricity or gas may either be inadequate or unavailable. Hot-water supplies are often non-existent. Modern-type sanitary accommodation may also be lacking. In quite a number of instances, the premises are entirely unsatisfactory from a structural point of view. Many such premises consist of a conglomeration of wooden huts or shacks, to which additions of various types have been made from time to time as trade has increased. The kitchen arrangements and food-storage accommodation are usually quite inadequate, while proper means of cleansing equipment, crockery and cutlery are conspicuous by their absence. No provision is generally made for personal ablutions. The heat in the wooden erections, frequently used as kitchen premises, may become almost unbearable during warm weather, owing to lack of adequate ventilation and faulty roof construction. Flies and other vermin often abound ; refuse may be disposed of simply by dumping at the rear of the premises.

Mobile vans are in the same category as roadside and transport cafés, the conditions under which they operate being in many cases even more unsatisfactory, if that were indeed possible. During the last few years there has been a considerable increase in the number of these vehicles, many of which are in use at sports meetings and other places where crowds gather and request food and drink. The vans themselves are too often converted vehicles of various types. They are frequently difficult to cleanse thoroughly, possess no hot-water supply or means of obtaining same, while prepared food is often displayed without the slightest protection from air-borne contamination or the elements. In addition, the methods employed by those persons preparing food quite often leave much to be desired.

(5) *Railway Buffets.* It has been suggested in some quarters that railway buffets and refreshment-rooms should be classified as ancient buildings, owing to the expenditure likely to be necessary were modernisation to be attempted. Originally provided for the sale of drinks of all types, together with cigarettes, tobacco, chocolate and cakes, these premises have, owing to consumer demand, added the supply of snack meals and, in many instances, the provision of full-scale meals to their original function. The result has been that such meals or snacks are often prepared in premises which are entirely inadequate for the purpose. The structural condition of many of these premises is often quite unsatisfactory, as they were never intended for catering purposes in the modern sense. Underground kitchens with low ceilings, inadequate lighting and poor ventilation may be in use. It is difficult to enforce cleanliness, while infestation with vermin of various types is encouraged. Facilities for the cleansing and sterilisation of the equipment, crockery and cutlery are often inadequate ; food may be exposed to atmospheric contamination on counters in an uncovered condition. Tables and counters are often inadequately cleansed, while kitchens are not maintained in that hygienic condition which is so essential in food-preparation premises. The inspection of most railway premises is so hedged with difficulties that doubts have been expressed as to the position of such establishments. It does appear clear, however, that all railway catering establishments, including railway hotels, are subject to the terms of the Food and Drugs Act, 1938, and that this includes the right of inspection by public health officials.

Improvement has, however, taken place during the last few years, since the nationalisation of the various railway companies and the formation of the British Transport Commission. A Hotels Executive was set up, and under their supervision great strides are being made in the improvement of catering methods in railway premises. Many of the old buffets have been closed, not only because of their inadequacy but also because they were no longer profitable. There is no doubt that greater improvements would have taken place but for the difficulty in meeting the capital cost required to modernise many of the premises.

(6) *Public-houses.* Great variation exists in the conditions usually found in this class of establishment, to which are closely allied registered clubs, where meals may or may not be served. The conditions found are mainly due to the age of the buildings and the methods of management. In modern licensed houses, the preparation and serving of meals is very often carried out under satisfactory conditions. Faults quite often exist, however, even in the most modern establishments. Apart from the unsatisfactory structural state of many licensed houses, due mainly to age or faulty design, kitchens are not always suitably placed or arranged. In many instances public meals are prepared in the kitchen used by the licensee and his family. Foodstuffs, mainly in the form of snacks, are frequently exposed for sale on counters without provision being made for adequate protection against contamination. In relation to the sale of drinks, there is often a lamentable absence of

suitable facilities for the cleansing and sterilisation of glasses, an absence which has been duly noted in the Report of the Working Party on the Hygiene of Catering Establishments. This is particularly noticeable during busy periods. Provision for the adequate cleansing of the pipe-lines which carry beer from the cellars may also be lacking. These are frequently dirty and in a state of disrepair. Some publicans make a practice of collecting over-spilled beer for subsequent re-sale, a practice which should not be tolerated, while there is too often a lamentable absence of suitable sanitary or cloak-room accommodation for patrons and for staff. In the supervision of such premises, close co-operation between the licensing authority and public health officials is essential if improvements in premises and methods are to be brought about, particularly as regards the storage, preparation and sale of food and drink. It must not be thought, however, that all licensed houses are unsatisfactory from a hygienic standpoint, or that proprietors and managers lack a proper sense of responsibility in every case. This is by no means so. The sanitary and general hygienic arrangements in many licensed houses are of high order. The fact that a minority fail to reach these standards indicates the need for more strict supervision, with the application of still further educative measures.

(7) *Municipal* (*Civic*) *Restaurants*. With Governmental approval, local authorities began to supply meals to the public during the War with conspicuous success, often in requisitioned premises hurriedly adapted for the purpose. Such alterations as were made were often carried out as a matter of extreme urgency, almost invariably at the least possible cost. Bearing these facts in mind, it is remarkable how successful these undertakings were. Now that they are to some extent a permanent feature of local government administration, many local authorities are showing concern at the conditions which exist in their premises. Where made, the cost of extensive alterations has in many cases been excessive, with the result that the restaurants concerned have had to be heavily subsidised from the rates to prevent losses. They have thus entered—not always successfully—into unfair competition with the private caterer. Present policy seems to favour the closure of many of these premises to prevent further losses. Unsuitable premises have also been closed in view of the prospective cost of alterations suggested as necessary. Owing to the limited type of premises originally available, it is often found that kitchen space is totally inadequate for its purpose. Food-storage accommodation is frequently insufficient, while ventilation and lighting may be totally unsatisfactory when set against optimum requirements. The same remark applies to the removal of fumes and steam. Drainage arrangements and refuse storage facilities are seldom adequate. In many instances the provision of sanitary accommodation for patrons and staff has been overlooked. It is to be regretted that public health supervision of such premises is occasionally opposed, and obviously resented, by the responsible council committee and its catering officer, where such an officer is employed. The Ministry of Food should make it clear to all local authorities that their catering establishments must be open to inspection by public health officials at all times. Indeed, the local authority should set an example to private traders in the management of their premises, and in the methods employed in the preparation and sale of meals. It will be apparent that the whole question of municipal restaurants is intimately bound up with their establishment during the War years as an emergency measure. The standards then accepted should not now apply. While the problems confronting local

authorities in the management of municipal restaurants may be viewed with sympathy, this must not be allowed to stand in the way of modern progress.

(8) *School Canteens.* As happened in the case of municipal restaurants, the growth of the school meals service was a rapid war-time development. Many of the buildings still being used for the preparation of meals are quite unsuitable, particularly in small and rural areas. One of the main defects found is the lack of suitable means of removing steam and fumes into the open air, while sinks in which the food is prepared are too often used for utensils and crockery washing and for the personal ablutions of staff. A further omission is the failure to provide suitable sterilising sinks, although it should be noted that many such are now being fitted. Suitable means for sterilising the heat-insulated containers in which meals are delivered to schools from a central kitchen are important, while low-temperature storage for both cooked and uncooked food should be regarded as essential. The fact that meals prepared in premises of the type described above are often consumed in the school hall represents a further disadvantage. Modern school canteens are now being erected to comply with the standard specification of the Ministry of Education. Such premises are excellent in every way. In some instances, however—mostly isolated—difficulties have arisen in connection with inspection by public health officials. It has, for instance, been reported that permission from the education authority is required before such an inspection can be made. This procedure is totally wrong and should not be countenanced. Fortunately for all concerned, liaison between the education authority and the public health department is usually cordial.

(9) *Industrial Canteens.* These are again very largely a war-time development. Generally speaking, a reasonable hygienic standard is maintained in such premises, particularly those installed in the larger factories. In many of the smaller undertakings, however, difficulties arise in the matter of cleansing and maintenance, the premises being unsuitable owing to lack of space due to hurried adaptation. The public health official has the right of inspecting such establishments under the Food and Drugs Act, 1938, although the Ministry of Health has stated that it is desirable for the factory inspector to be consulted before any such inspection is carried out. This seems to be a retrograde step which is without value, and one which is likely to limit materially the very necessary supervision of such premises. In addition, an increasing number of private canteens are now being operated, in relation to which the terms of the Food and Drugs Act, 1938, do not apply. The methods there employed and the premises used should be brought within the scope of legislative control. If this is not done, meals served in such premises can be prepared under the most undesirable conditions without proper supervision being exercised.

It would not be too much to say that the whole matter of the inspection of kitchen premises by public health officials calls for overhaul. What, for instance, is the position of the hospital kitchen ? How far do the restrictions which apply to Crown property affect the public health official in his work ? These and many other questions should be settled, so that responsibility can be squarely placed on the shoulders of those willing and able to accept it. It should be noted that this applies not only to the inspection of these premises, but also to the investigation and control of such cases of communicable disease by the local medical officer of health as may arise in or from such establishments.

General Defects in Catering Establishments

Unsatisfactory conditions are likely to persist in any or all of the types of premises discussed above unless proprietors fully appreciate that a proportion of the money available for improvement must be spent on the kitchen and food-storage accommodation and not solely, as is so often the case, on the rooms in which the finished meals are served. As already indicated, many premises used for catering purposes have been badly adapted for their purpose, little regard having been paid to essential requirements in relation to food preparation and handling. Again, premises which may have been originally satisfactory have been rendered unsuitable by reason of increased business. Most faults lie in the direction of failure to provide adequate food storage, while the design of kitchens and the siting of equipment often renders thorough cleansing difficult if not impossible. The need for adequate ventilation, with consequent speedy removal of fumes and steam, is often overlooked, while dangerous economies are frequently practised in respect of facilities available for the cleansing and sterilisation of utensils, cutlery and crockery. Sinks installed for the preparation of food and for washing utensils are too frequently used by the staff for personal ablutions. Drainage is often poor, while the accommodation provided for the storage of refuse may be totally inadequate. Adequate provision is seldom made for the wearing of washable overalls and head coverings by kitchen employees ; proper *ad hoc* accommodation for the storage of outdoor clothing and personal belongings is rarely available, except in the case of more up-to-date establishments. The sanitary accommodation for both patrons and staff may be inadequate and is frequently badly sited, too near the kitchens. The continued use of damaged or chipped crockery is still too prevalent. It must be admitted that crockery was difficult to obtain during the War years, and that too much emphasis need not be placed upon the possible dangers which follow the use of cracked or chipped crockery. None the less, although choice of type may be limited, crockery is now available, and should be in a satisfactory condition. Indeed, until more information is available as to the possible danger to health, the use of damaged crockery might well be prohibited. Food is frequently exposed to various forms of contamination, while dirty or unsuitable tables with soiled table coverings are all too common.

In addition to the specific defects listed above, there is a serious lack of knowledge concerning the elementary principles of kitchen hygiene on the part of many employers and employees. Worse, perhaps, a proper sense of responsibility is too often lacking. This is in some ways understandable when the terms of employment of many catering trade workers is remembered. Much of the work is seasonal, particularly in seaside and holiday resorts. Temporary employees can scarcely be expected to display the keen interest in their work which might be the case if permanent employment were available. Furthermore, a poor type of employee is often utilised for what are considered the more menial kitchen tasks, such as vegetable preparation and the cleansing of utensils and floors, although these are, in fact, responsible duties. Added to this is the fact that many foreign nationals are now employed in kitchen work. In too many instances their appreciation of the hygienic principles involved leaves much to be desired. The effect of the operation of the Catering Wages Board has, in the case of many holiday resorts, had the effect of closing premises during the off-season which would otherwise have remained open. This has added to the difficulties associated with temporary seasonal employment. The education of food handlers so employed presents a very real problem.

Design and Construction of Kitchen Premises

The smallest kitchen should have a minimum *floor area* of 100 square feet. Proportionate increases in floor space are required according to the volume of trade carried on. Each kitchen operative should have 33 square feet of floor space, clear of furniture and fittings, in which to work. *Floors* should be constructed of some non-absorbent material and should be provided with a smooth non-slip surface, in addition to being rat- and vermin-proof. Many kitchens and food-preparation rooms are provided with cement concrete floors. While these are impervious to moisture, they cannot be considered entirely satisfactory. Grease will be absorbed by the cement finish. This cannot be subsequently removed, so that the floors tend to erode quickly, while they are difficult to clean and to keep clean. Such floors can, however, be treated to render them less dusty and to prevent grease absorption. Asphalt floors are soluble by grease and oil and quickly deteriorate. Composition floors are similarly affected. Probably the best flooring material is *quarry tiles* laid in cement, or *terrazzo paving*. Hard smooth-faced tiles are to be preferred as being less absorbent, although they tend to become slippery. They are, however, easily cleansed. All *angles* between floors and walls should be coved. Existing wooden floors can be covered with tiles by the use of expanded metal. Floors should be given sufficient slope so that water will run off to trapped gullies.

Wherever possible *wall surfaces* should be finished with light-coloured tiles to ceiling height. A minimum requirement should be wall tiling to a height of 5 feet, the surface above this level being finished with a light-coloured glossy paint. *Colour* is important. A suitable colour will impart an attractive appearance, reflect light, look clean and give clear indication of the presence of dirt. Hollow walls should not be permitted, particularly when adjacent to ovens or hot-plates. Such cavity walls are likely to become infested with crickets, steam flies or beetles.

Ceilings should be underdrawn and exhibit a smooth continuous surface. In kitchens where quantities of steam are likely to be present ceilings should not be painted, owing to possible condensation. If this point is forgotten, moisture may drop into and contaminate food which is being prepared beneath. Plaster ceilings are absorbent and quite satisfactory provided they are maintained in good condition. They should be decorated as often as necessary with light-coloured distemper.

Inadequate attention is frequently paid to *food stores* in catering establishments, the presence of vermin in such rooms being too often accepted as a matter of course. Food-storage rooms should be provided with solid floors, walls and ceilings. Windows and doors should be tight-fitting so as to be completely vermin-proof. Existing rooms can be made vermin-proof by the use of sheet metal. Hollow wooden walls can be covered with aluminium sheets or with expanded metal, which can be rendered with cement to ceiling height. Wooden floors can be tiled or cemented on expanded metal, while ceilings may be covered with metal sheeting. Whatever is done, a variety of foods, such as flour or cereals, should be stored in metal bins or similar containers. Cold-storage accommodation for perishable goods should be regarded as essential, the provision made varying with the volume of trade carried on and the quantity of food to be stored. *Refrigerators* should not be placed in any kitchen where cooking is carried on. They should be sited in a separate room or larder, distinct from the food store, where left-over foods can be kept cool. Vegetables should be prepared and stored separately, particularly where the volume of business is substantial.

Ventilation of kitchen premises is frequently unsatisfactory. Steam and other heated gases are best disposed of by grouping all cooking equipment together, preferably in the centre of the room. A suitable hood or canopy can then be provided over the equipment, connected by means of a duct to an exhaust fan of the centrifugal type. The fan must exert a strong pull to prevent the escape of gases outside the hood and to ensure that all vapours are rapidly drawn into the duct and so expelled into the open air. Expulsion should take place at sufficient height above the ground or surrounding buildings to prevent any nuisance arising. Whenever practicable, the fan and motor should be situated at some distance from the kitchen to prevent possible annoyance from noise. If this cannot be arranged, all available steps should be taken to ensure that there is no nuisance to the employees when the fan is in operation, otherwise it may be switched off by the workers themselves on this account. The kitchen should possess at least one outside wall, in which adequate inlet ventilation should be provided. In certain instances it may be necessary to provide some type of mechanical inlet ventilation to supply additional fresh air. This will probably be an essential requisite in the case of basement kitchens. Inlet ventilators for such premises should be placed well above ground level in order to keep out dust and dirt. The openings should be protected from the entrance of rain or falling dust. At least one fresh-air inlet duct should be provided wherever possible to discharge its air in the hottest part of the kitchen. While the ventilation arrangements for each part of the premises should be adequately separated, this is more important still in the case of sanitary conveniences.

Windows should be of the casement type so that they can be fully opened during warm weather. Hopper windows should also be provided. Wherever possible, the size of the window openings should be at least one-tenth of the floor area. It is also essential that adequate *lighting* be installed. Natural light should be provided wherever possible ; suitable artificial, light preferably by the use of fluorescent tubes, should also be available. If adequate artificial light and ventilation are provided, the provision of natural light ceases to be a prime necessity.

Separate *staff accommodation* is highly desirable, but cannot be demanded if the staff take their meals in the restaurant after the normal service is completed. Suitable means must, however, be provided for storing each employee's clothing. *Changing rooms* may also be required. Each employee should be provided with a separate *locker* for clothing and personal belongings. A lock and key should be available so that nothing need be taken into the food-preparation rooms. Adequate *sanitary accommodation* for the staff is essential and should be separate from that provided for the use of customers. Male and female employees should have separate accommodation, provided with suitable approaches and properly screened, a minimum of one w.c. for each twenty-five persons being required. Wash-basins in the ratio of one for every ten persons are necessary, and should be fixed in the ventilated approach to the water-closets. All doors should be self-closing. Washing facilities *must* be conveniently sited, while adequate supplies of hot water, soap and *clean* towels are essential. It is virtually useless to expect employees to use wash-basins which are hidden away in inaccessible corners ;

the absence of hot water, soap and towels will further invalidate the success of any provisions made. Washing, even in the adult, is unfortunately not always a natural function. Everything possible must therefore be done not only to educate the personnel in the urgent need for such a practice but also to render the operation as easy as possible. Notices regarding hand-washing should be prominently displayed in w.c. compartments and also over wash-basins, while the provision of nail-brushes is strongly to be recommended. Hot water should be provided *directly* over the basins and should not have to be carried from some source outside the cloak-rooms. An additional wash-basin in the kitchen will be found most useful. It need scarcely be emphasised that employers have a serious duty laid upon them of ensuring that the facilities provided are fully used. As is the case throughout the food-handling industry, precept and example are of paramount importance.

Clean overalls and head coverings should be provided for the employees and should be laundered frequently. Finger-nails should be kept clean and short. The use of nail varnish need not be prohibited provided such varnish is not employed to mask underlying dirt. Any employee suffering from an infectious disease, from colds, skin eruptions or from digestive disorders should be prohibited from handling foodstuffs until a medical practitioner has certified that he or she may safely do so. A *first-aid box* or cabinet should be a standard fitting in every kitchen. Employees should be taught the proper use of the dressings and equipment available, especially the need for covering all skin wounds or abrasions with the right type of dressing.

Kitchen Equipment

The provision of suitable equipment for the preparation of meals is an essential requisite in the catering industry. It is particularly important that the *siting of equipment* should be correct, since in the majority of instances it will be found that, when compared with the dining space, the kitchen space is much too small. It has been stated that an allowance of 3 square feet of kitchen space for each diner is adequate. This appears reasonable. Such provision should include space for vegetable preparation but should exclude any rooms required for the storage of food. As already indicated, *cooking equipment* should preferably be sited away from walls. When this is not practicable, equipment placed alongside walls should be at least 12 inches from the wall surface, so that adequate space is available for cleansing at the rear of the appliances. All *wall shelves* should be given 1 inch clearance so that cleansing at the rear of the shelves is facilitated. *Slatted pan racks* are sometimes provided. These are more difficult to cleanse than ordinary shelves. *Plate racks* should be designed so that they are easily cleansed. Any drips should be collected in a suitable tray provided with an outlet pipe. All *tables and benches* used for food preparation should have smooth, impervious upper surfaces, free from joints and crevices. Stainless steel or marble tops are eminently suited to this purpose. All tables and benches should have castors fitted to allow for easy movement. If provided with shelves, these should be fitted at least 12 inches from floor level. *Bins* used for waste food or swill should always be provided with tight-fitting lids and should be maintained in a clean condition. They should be removed daily for cleansing and fresh bins substituted. An adequate number of *sinks* should be provided. When used for dish-washing, they should be constructed of stainless material provided with drainage accommodation fashioned from similar metal. This has been found to be the most efficient substance for the purpose in spite of high initial cost. Wooden sinks, often of teak, are frequently provided, being popularly held to reduce the possibility of breakages. Stainless steel or even vitreous enamel sinks are equal to wood in this respect and are definitely more hygienic. If desired, shallow fine-meshed metal trays may be provided. These form an excellent cushion for a sink or draining-board and are preferable to rubber mats, which are not easily cleansed. Aluminium sinks are sometimes fitted. These are not so strong as stainless steel, score easily with rough usage and are then difficult to cleanse. Stainless or glazed earthenware sinks may be provided for vegetable washing. Those used for the cleansing of pans and similar utensils may be constructed of galvanised iron. The front edge of all sinks should not be more than 3 feet above floor level. The water-supply pipes, preferably of copper, should be fixed vertically either above or below the taps, so that no dirt can find lodgement. Lead pipes are often found fixed horizontally to a wooden board. This practice permits dirt to collect in a situation from which it is difficult to remove.

A separate washing sink or sinks should be provided for both crockery and vegetables, even in the smallest café or restaurant. The size of the sink is important. As a general principle sinks should not be too large. If an unnecessarily large sink is installed frequent changes of water, which are so desirable, may not be necessary. It is also generally accepted that all sinks are best fixed on tubular supports 6 inches from the nearest wall. The underlying space should not be occupied by cupboards or other fixtures. Large-diameter trapped waste pipes should always be provided, discharging in the open air into back-inlet gullies or grease-intercepting traps. Abundant *hot water* must be available at all times. This is vitally important. It is often found in practice that many kitchens have water-heating systems which are totally inadequate to ensure sufficient hot water at the correct temperature as and when required. Whatever system is installed should be adequate to supply all needs. The quantity indicated depends upon the volume required for washing pots and pans, for cooking purposes and for general use. The type of dish washing in use, whether hand or mechanical, must also be borne in mind. When mechanical methods are employed, the type of apparatus is important. The volume of dishes to be handled, particularly at rush periods, must be studied, as must the general efficiency with which the equipment is operated. Coal, oil or gas may be employed for heating purposes. Before any apparatus is installed a detailed estimate of probable needs should be made. The fitting of large booster heaters or water-storage systems has been found useful in supplementing hot-water supplies and in securing adequacy at busy periods, when exceptionally large quantities may be required. Long pipe leads from the source of hot water to the point at which it is to be used should be avoided. This will prevent heat losses. Water and gas *pipes* should always be enclosed in insulating materials and provided with a smooth finish and painted externally. Pipes should preferably run in a vertical direction and be fixed at a distance of at least 1 inch from the wall surface. If horizontal runs cannot be avoided, pipes should be fixed well clear of the floor.

Kitchen Methods

The methods employed in kitchens and food-preparation rooms are of great significance. Unhygienic practices should be abolished. Such practices include smoking by the kitchen staff while at work, wiping utensils with dirty cloths, and the handling of food with dirty hands. All rooms used for cooking and the preparation of food should be cleansed at least once daily.

The thorough cleansing of utensils and equipment is of the utmost importance. Epidemiological data in regard to disease outbreaks due to dirty utensils is not extensive, but sufficient bacteriological experiments have been carried out to show that the transmission of disease from person to person is possible when unclean containers and utensils are used. Much educational work remains to be done, to ensure that the cleansing of utensils is carried out in an adequate manner. Practical improvement is very definitely required so far as existing methods are concerned. The various factors involved include the method and equipment employed, adequate maintenance, the detergent used, the volume of hot water available, the methods of sterilisation in use, the storage and handling of soiled and clean dishes, and the methods practised by the individuals personally responsible for the work.

Detergents are of considerable importance, exercising as they do a definite effect upon the final result. A variety of suitable detergents are available. Any detergent used should possess the following properties :

(1) *Wetting*, or the ability readily to moisten the utensils being cleansed.

(2) *Emulsification* of any fat which may adhere to the utensils.

(3) *Dissolving*, or the ability to dissolve food materials, particularly proteins.

(4) *Deflocculation*, to break up particles of dirt.

(5) *Dispersion*, or the ability to function adequately in hard or soft water, thus preventing the formation of a film or deposit of mineral salts and similar substances on utensils and equipment.

(6) *Rinsing*, which ensures that clean water will completely remove all detergent traces when utensils are finally treated in this way.

No one detergent possesses all these properties ; none is therefore 100 per cent. effective. Mention must, however, be made of certain *detergent ingredients*. *Soap* is a good detergent when used in soft water, but has no dispersion properties and only limited emulsive and deflocculation properties. With hard water the reaction of the soap and the constituents governing the degree of hardness in water results in the formation of insoluble soap, which leaves a deposition on utensils and equipment. *Sodium hydroxide* is a good dissolving agent but lacks certain important properties, while it is liable to prove dangerous to the eyes and skin. *Sodium carbonate* possesses the normal alkaline properties and is a good water softener. Owing to its reaction with water, it precipitates film. *Trisodium phosphate* exhibits satisfactory emulsifying and deflocculating properties but is not a completely effective detergent by reason of inadequate wetting and dispersion properties. Trisodium phosphate is, however, a useful water softener. *Sodium metasilicate* has similar detergent properties to trisodium phosphate but exerts a less corrosive action on certain metals. *Sodium hexametaphosphate* is an effective water-softening agent and has excellent dispersion properties. It forms soluble compounds with the calcium and magnesium salts in hard water, thus preventing the formation of film on utensils and of scale and sludge in sinks and dish-washing machines. Otherwise it possesses little detergent properties. *Tetrasodium pyrophosphate* and *sodium tetraphosphate* exhibit similar properties.

Sulphated alcohols, which are used as wetting agents and combined in detergents, have definite emulsification and deflocculation properties which ensure that objectionable films and precipitates will be avoided. Their usefulness is, however, somewhat limited as they readily produce foam. Thus, only a small quantity can be combined with the detergent used in dish-washing machines if the development of excessive foam, which will interfere with washing operations, is to be avoided. A number of other substances are used in detergent compounds to decrease the risk of violent alkaline reactions and to minimise corrosion of metal sinks and dish-washing apparatus. *Inert abrasives* are sometimes incorporated but are generally considered undesirable additions to detergents used for dish washing. Detergents should not leave any film on glassware, so as to obviate cloth drying, while the concentration effective for efficient washing should exert no irritant action upon the skin of the worker. Generally speaking, a satisfactory detergent is a mixture of a number of different chemicals, each possessing certain essential properties. Whatever detergent is selected, care should be taken to ensure that it is suitable for use with the type of water available. Most detergent manufacturers are only too willing to provide such information so that the purchaser will be completely satisfied. Broadly, the factors which decide the choice of a detergent are (*a*) the hardness of the water, (*b*) the equipment in use, (*c*) the temperature and (*d*) the concentration. In practice a concentration of 0·4 per cent. is generally considered satisfactory. This may vary with the various detergents available. Remember also that the pH value should not be overlooked.

The methods employed for *dish and glass washing* substantially depend upon the quantity of articles to be dealt with each day. The standards of washing crockery, glassware and cutlery are highly unsatisfactory in many restaurants, so much so that visitors from abroad are often shocked at what they are shown. An entirely inadequate volume of dirty, greasy, lukewarm water is employed for long periods in many kitchens ; after they have drained, the dishes are frequently wiped with a damp dirty piece of cloth or towelling. When *hand washing* is employed, dishes, cups, plates silverware and food containers should be washed separately from glassware, even in the smallest establishments. The equipment available for this purpose is not so important as the efficiency of the methods employed, although suitable sinks should always be provided. If chemical sterilisation is provided as the final treatment, a three-compartment sink will be required. *All* compartments should be provided with a plentiful supply of hot and cold running water. The hand-washing methods employed in restaurant kitchens are primarily those used in the home, being applied on a much larger scale. Although dish washing in the home is often looked upon as a humble, relatively unimportant operation, this conception must never be allowed to apply to any catering establishment. To consider dish-washing as an unskilled task, as is so often the case, will almost certainly lead to unfortunate results. The first essential step in the process is to remove all food scraps remaining on plates or other utensils by scraping. As an additional aid to efficiency, pre-rinsing is to be recommended. Pre-rinsing assumes even greater importance when modern crockery is in use. Crockery is usually only available to-day in " seconds " quality. It is not uncommon for such crockery to crack when first placed in hot water. If warm water is employed for pre-rinsing purposes, the articles will be suitably tempered before entering the hot washing water. Removal of food scraps and pre-rinsing reduce contamination of the water and prolong the useful life of the detergent.

Utensils should be roughly sorted into various sizes and should then be immersed in hot washing water containing detergent. Cups should be placed in baskets with the handles uppermost and the mouths turned away from the operative. In this way the cups will all be filled with water, while the buoyancy of the liquid will not force them out of the basket. The basket and its contents should be removed at the same angle so that all cups empty as they emerge. The wire baskets should be placed in multi-tiered metal storage racks. Since the handles should still be uppermost, it is most likely that they will be used for removing the cups. The temperature of the washing water should be in the region of 120° F., being as hot as can be borne by the hands of the operator. Water at this temperature facilitates washing operations and assists in reducing the bacterial content. During operations the water should be changed frequently, otherwise the soap or other detergent will be rendered ineffective. Manual labour is also essential in the removal of adherent materials. It must again be emphasised that washing operations are of the very greatest importance, since effective chemical sterilisation cannot be accomplished unless the articles are really clean. All utensils should be rinsed in clean warm water prior to sterilisation. The rinsing water should be frequently changed to prevent fresh bacterial contamination. The washed articles should be stacked in galvanised wire baskets and placed in the second compartment of the sink. This compartment should contain hot water at a temperature of 170° F. to 180° F. This temperature can be profitably maintained by means of thermostatic control. Articles should be thoroughly immersed for the two to three minutes during which they are in contact with the liquid. An adequate temperature cannot be maintained by the addition of further quantities of hot water at intervals. Thus, gas or electricity should be available to provide constant heat to the water in the tank. Wire baskets are essential because of the temperature of the water. These baskets must be kept clean at all times. Equipment which cannot be treated in this way owing to its size may be sprayed with live steam from a hose or with chlorine solutions. It may also be boiled in water.

If the final treatment is *chemical sterilisation*, the articles should be removed to the third compartment of the sink and immersed in a suitable hypochlorite solution (chlorine strength, 100 parts per million) for two minutes, after which they may be allowed to drain or be wiped. The chlorine strength should never be allowed to fall below 50 parts per million. Sterilisation in a suitable steam chest could be more widely employed than is at present the case. This apparatus might also provide a useful storage for clean utensils, while it could form an additional method of warming utensils, particularly plates. When *towels* are used for wiping, they should be frequently washed and sterilised, as unclean cloths can add large numbers of bacteria to the utensils. All drying cloths should be kept clean and dry. A heated cupboard is essential for this purpose. *Self-drying* of utensils in the atmosphere is always preferable to wiping with cloths or towels, while *hot-air oven drying* or *special machine driers*, used in large establishments, might also be considered. Cutlery is almost invariably washed by hand, the methods outlined above being available. Silver and silver-plated ware should not be treated with chlorine solutions, as the surfaces will blacken due to the formation of silver chlorides. Hot water only should be used for the final treatment of such articles.

Glass washing is usually a separate operation and is especially important in hotels, soda-fountain and ice-cream premises. The method of hand washing should follow closely upon the lines set out above for dish washing. A preliminary rinse should be followed by washing in hot water containing a suitable detergent. The chosen detergent should have good wetting properties, increased efficiency being obtained by the use of brushes, either operated by hand or by a rotary motor. Friction by means of bristles is useful in removing food soilage. Several sets of brushes are required. Those in use should be boiled daily and changed at least once each week. After washing, glassware should be rinsed in the second compartment of the sink. The water should be as hot as the hands will stand. Rinsing removes any remaining material and all traces of the detergent, and also assists the action of any chemical sterilising agent which may be used. As before, the strength of the hypochlorite solution should initially be 100 parts per million, and this strength should never be allowed to fall below 50 parts per million. An exposure period of two minutes is recommended. The articles being treated can either be left in the solution for this period or may be totally immersed and then removed, being allowed to drain for two minutes. Either method is satisfactory provided the solution is allowed to remain in contact with all surfaces for the requisite period. Sterilising solutions may be used either hot or cold, as circumstances dictate. A cold solution of the required strength is quite efficient. Glasses should always be handled by their bases and should not be stored on wooden shelves or on towels. Wire racks of a suitable type should always be available for the storage of clean glassware. These racks should be maintained in a clean condition.

Where large quantities of crockery and other utensils have to be dealt with, *mechanical washing* is strongly recommended. This method will give excellent results if properly carried out, the *mechanical washer* being a commonplace piece of equipment to-day, particularly in the larger restaurants. Quite a number of these machines, however, rely upon the washing operation only, providing no sterilisation either with chemicals or any other agent. While mechanical washing partly eliminates the human factor in dish-washing operations, it does not follow that this method is more satisfactory than is the case where proper and efficient hand washing is employed. As with hand washing, dishes and plates should be scraped and pre-rinsed to remove all food traces. Washing should begin as soon as possible thereafter. This will minimise the drying of food particles on the surface of utensils. The washing water should be maintained at a temperature of 140° F. by means of thermostatic control. A satisfactory detergent of suitable concentration should be used. A *detergent dispenser* may be provided which will automatically control the addition of these substances. The quantity of detergent required varies according to the hardness of the water, and should be adjusted accordingly. If a 6-grain hardness is present it is recommended that ¾ ounce of powder for each 5 gallons of water should be added after twenty minutes' operation. Detergents should always be selected according to the chemical composition of the water available. Spacing or racking of the utensils in the apparatus, so that all surfaces are exposed to the full force of the washing and rinsing solutions, is an important consideration. No overcrowding should be allowed. There should be no nesting of the vessels, while the various articles must be placed so that the sprays can operate properly. Detergent solutions should be allowed to act for at least one minute. Care must be taken to ensure that this period is not reduced during rush hours. Sterilisation in mechanical dish washers is usually carried out by means of hot water at a temperature of 170° F., the utensils being exposed for a period of thirty seconds. Much lower periods of exposure are often used. When this is the case, it is highly problematical whether the process can ever be successful. Water temperatures must always be thermostatically controlled. Thermometers should be provided to all washing and rinsing tanks so that they are easily visible to the operators. Jets should be quickly detachable for cleansing purposes. After treatment has been completed the utensils should receive a minimum of handling and should be suitably stored in a clean place. Many of the latest machines are fitted with drying apparatus. Even in the older models a temperature of 170° F. should allow the dishes to drain rapidly and dry themselves. The use of towels following mechanical treatment should always be discouraged, as contamination can readily be carried by the towel from one article to another.

The *design of mechanical dish washers* varies considerably. Three main types are commonly found. The simplest type requires that the dishes be loaded by hand into a rack which can be pushed through the machine. Flat articles are stacked in an upright position. Streams of water, heated either by means of electricity or gas, are pumped from the washing-water storage tank through stationary or rotating washer arms, the dishes being subjected to the flushing action of hot water and detergent. When the second rack is loaded, it is pushed into the machine, the first rack being pushed out. In some types of apparatus a re-circulation rinse is provided before the final hot-water spraying takes place. Hot-water sprays treat the utensils in the outgoing rack before the rack is removed. Such sprays are operated either by hand or mechanical means. The jets may be straight but are more often set at different angles. Some machines of this design carry the rack slowly through the apparatus by means of a conveyor chain. In other types the rack rocks backwards and forwards during the operation. Both single- and double-tank machines working on this principle are available.

A belt-drive or conveyor machine is also available, the dishes being placed face downwards on an open flexible metal belt which slowly moves and revolves. The washing water is forced by means of a centrifugal pump through jets which spray the dishes passing through. Hot-water sprays are applied as the dishes approach the outlet. The human element is eliminated to a greater extent with this apparatus, but wash or rinse jets must be kept open if the treatment is to be satisfactory. A semi-mechanical type of washer is also employed. A certain degree of manual operation is involved when this type is used. The soiled dishes are placed in a long-handled basket which is fixed into a rocker operated either by hand or by means of an electric motor. The basket and its contents are rocked backwards and forwards in the washing water. This exerts a modified scrubbing action on the utensils. After the washing operations have been carried out, the basket is removed and immersed into a second compartment for sterilisation purposes. Reasonably good results are obtainable if the preliminary treatment of the dishes has been satisfactory. Gas or electrical heating of the water may be employed.

Machines fitted with timing devices which prevent the operator from changing or varying the operations can be obtained. Apparatus of this type will not operate until the water reaches a pre-arranged temperature. The time of exposure of the utensils to the washing and rinsing waters is fixed and cannot be varied. A mechanical glass washer is also obtained. The glasses are inverted in wire racks and set in a movable carriage in a washing tank. On depression of a lever the rack and its contents are submerged in the washing water. The glasses are cleansed both inside and out by means of suitable brushes. The tray is then brought over the rinsing jets. Depression of another lever causes them to be sprayed with hot water, after which they are dried by means of hot air distributed by a fan. In the United States of America, sterilisation of glassware after thorough washing has been satisfactorily carried out by means of ultra-violet rays. In place of the hot final rinse, hypochlorite treatment may be given in all machines. Before this is done a preliminary rinse is required to remove all detergent solution. The strength of hypochlorite solutions should not be less than 100 parts per million, and they should not be allowed to fall below 50 parts per million. These solutions should be prepared daily as required and should never be carried over to the succeeding day. Many operators fail to appreciate the fact that the solution used should always be of suitable strength. This point requires constant attention.

Utensil Storage

When dishes, cutlery and other utensils have been properly cleansed and sterilised, it is imperative that they be suitably stored to prevent subsequent contamination. All china and glassware must be stored in a clean, dry place. China should be stored in cabinets and cupboards ; glasses should be inverted and stored in wire racks or in wire baskets. The storage place should be sufficiently high above floor level to afford protection from dust, dirt and other forms of contamination. Cutlery should be stored in metal bins, knives, forks and spoons being kept separate and placed so that they can be readily removed by the handles. Shelves or suitable hooks, fixed well above floor level, should be used for the storage of pans, cooking utensils and similar equipment. When single-service containers are used for beverages, they should be purchased in suitable cartons, in which they should remain until required for use. Such cartons should be stored in a clean, dry place ; the containers should be handled in a hygienic manner. All equipment used for handling or dispensing footstuffs, such as scoops, dippers, tongs or cutlery, should be stored at all times in such a manner as to minimise the risk of contamination after cleansing. One of the weak points found in otherwise well-run kitchens is the lack of care exercised in dealing with utensils, cutlery and crockery after they have been properly cleansed and sterilised. Stress must always be placed upon this aspect of kitchen hygiene and upon the urgent need for the suitable storage of such articles until required for further use.

Legal Control

The present legal control with regard to kitchen hygiene in catering establishments is based mainly upon the Food and Drugs Act, 1938. Section 13 of this Act prescribes provisions as to " rooms " used for the preparation, storage or sale of food. This section could be profitably revised. Thus the word " room " should be amended to include stalls, boats and mobile vans. The terms of section 13 do not cover goods supplied in clubs, private canteens or institutions, nor is mention made of the need for the adequate lighting of food rooms. The desirability of a constant supply of hot water for cleansing utensils should also be included in this section, while provision might with advantage have been made to require at least one lavatory basin to be installed for the personal ablutions of employees. Further points which appear worthy of inclusion are (*a*) the exclusion of domestic animals from all rooms used to the storage and supply of food, (*b*) prohibition of smoking during the handling of food, and (*c*) adequate fly- and vermin-proofing. There is no comparable legislation in force in Scotland except in so far as the provisions of this section have been incorporated in local Acts.

Section 14 of the Act of 1938 provides for registration by the local authority of premises used for the manufacture, storage and sale of ice-cream and certain prepared foods. This by no means covers all the ramifications of the catering trade. The registration of catering establishments, including mobile vans, should be insisted upon. This would mean that all premises in which meals are provided would be known to the controlling authority, while such an amendment would permit the refusal or cancellation of a registration where the premises were unsuitable or had become unsuitable subsequent to registration. If and when made, all such registrations should be valid for a period of twelve months, and after this period should be renewable at annual intervals, due regard being paid to existing conditions. Any change in ownership or management or any other alteration affecting registration should be compulsorily notifiable to the local authority. Arrangements in force in certain parts of the country, whereby a certificate from the local authority stating that premises are suitable from a public health viewpoint should be made available to the appropriate food executive officer before any new catering licence is granted, have been found to be of great value in promoting better standards of food hygiene.

Registration would help to ensure that conditions were satisfactory from the outset. Prospective caterers would be fully aware of what was required and would be in a position to decide whether or not to continue with the project proposed. Registration would also make possible stricter control of basement kitchens, while any proposed alterations to premises would have to be approved by the local authority before the work was begun. Provision should also be made for the methods employed in the cleansing and sterilisation of utensils, crockery and cutlery to be laid down. This has long been the case in relation to the production and distribution of milk (Milk and Dairies Regulations, 1949, and previous legislation). There appears to be no valid reason why the methods therein specified should not be legally demanded of the catering trade. The use of damaged utensils and crockery should be prohibited and the prevention of access to premises by rodents required. The unnecessary handling of foodstuffs should be prohibited. The possible inclusion of a clause requiring periodical medical examinations of kitchen personnel might be considered, although this is not an easy matter to decide. Initial medical examinations should certainly be required, while power should be given to exclude all food handlers who are obviously ill or who are likely to contaminate food, until they are completely recovered as certified by a medical practitioner. Section 14, it should be noted, does not apply to Scotland.

Section 15 of the Food and Drugs Act, 1938, enables bye-laws to be made in respect of the handling and wrapping of food, together with the sale of food in the open air. This section may apply to certain sections of the catering trade. Model bye-laws (see Appendix 2) having close relation to these matters were issued in 1949. These give any local authority who decides to adopt them wide powers designed to assist in the control of food handling and delivery. They are generally applicable to all branches of the food trades but make no attempt to lay down a hygienic code of practice for any particular section. Certain provisions relating to nuisances, the provision of water supplies and sanitary conveniences applicable to buildings used as catering establishments are to be found in the Public Health Act, 1936. In Scotland, some local Acts provide powers similar to those conferred in section 15 of the Food and Drugs Act, 1938.

Kitchen Inspection and Control

The inspection of kitchens in all catering establishments should be carried out at frequent intervals. The routine adopted should be such that no essential point is overlooked. The food-storage room or rooms should be visited first, followed by the kitchen accommodation, food-preparation rooms, bakery (if any), staff rooms, staff sanitary accommodation, dining-rooms, and service counters. The sanitary accommodation provided for the customers should finally be inspected. In licensed premises, the beer and wine cellars should be inspected frequently. In large restaurants, the time devoted to making such an inspection may be considerable but will never be wasted. Scrupulous care should be taken to ensure that no part of the premises is overlooked.

The condition of the floors, walls and ceilings should be noted. Differentiation should be made between any trade wastes likely to be present, and undesirable conditions not normally associated therewith. Particular care should be taken to ensure that the methods of cleansing, both as regards premises and utensils, are investigated. For this reason, inspections should be made at varying times, so that the state of the kitchens and other rooms can be seen during and after working hours. The presence of stale food, debris, grease and dirt should be carefully investigated. Statements made by those present or in charge as to the time during which such filth has accumulated should be accepted at no more than face value. The condition of the floors should receive particular attention, since it is common practice to mop over floor surfaces without first removing grease and other debris. In extreme cases the actual floor surface may be entirely hidden.

Larders, cold-storage rooms and refrigerators, fittings, equipment and utensils should receive careful attention, as well as structural fittings and the state of repair in each room. The methods employed in washing and sterilisation of utensils should equally be investigated. When chlorine solutions are employed for sterilisation purposes, the strengths of such solutions should be frequently tested by means of one of the portable testing sets available for the purpose. The final condition of the utensils can be determined by the application of a light dusting of powdered charcoal to their surfaces. This dust will adhere to the soiled spots, when a hand lens can be used to bring out grease spots or finger marks. Rinse or swab tests, employing sterile water or Ringer solution, can be made with various utensils and submitted to bacteriological examination. While laboratory sterility cannot be expected under commercial conditions, there should be less that 120 organisms per millilitre present on the surfaces of properly-treated vessels if cleansing and sterilisation has been carried out in a satisfactory manner. Ventilation methods must be noted and also the provision made for the storage of employees' clothing. Working clothing requires to be maintained in a clean condition ; the hands of the personnel should also be carefully noted. Any evidence of rodent or vermin infestation should be sought ; the drainage system and the methods of refuse storage must also receive proper attention. The methods employed by staff in handling foodstuffs and utensils should receive special notice.

Much depends upon adequate management of the premises. Even where structural difficulties exist it is usually possible, with suitable supervision, to implement all necessary hygienic requirements in regard to food preparation and handling. Unfortunately, the converse also occurs. Well-designed and well-equipped premises may easily become a danger to health owing to carelessness on the part of the owner, manager or employees. Education in hygienic food handling is of paramount importance. Personal hygiene in the kitchen and food preparation rooms is a vital factor and will always remain so, irrespective of the structural conditions of the premises. In many parts of the United States of America it is now the practice of the controlling authorities to place restaurants, cafés and snack bars into grades A, B or C, a code of practice having been established for the catering industry. Any restaurant which falls below Grade C standard is prohibited from operating. Some such standard might with profit be instituted in this country, and would almost certainly be welcomed by the best elements in the catering trades, despite the fact that the Catering Trade Working Party, in their Report, did not consider this method of control suitable for adoption. It is admittedly a drastic method, but conditions in many cases are such that drastic measures are necessary. Grading might first be carried out on a voluntary basis, but there is no reason why the position should not be legalised at a later date. Any proposal which holds out the hope of improving existing standards of kitchen hygiene is to be welcomed. No avenue should be left unexplored. Too much is at stake ; too much leeway has to be recovered. Finally, it must always be borne in mind that the standards reached and maintained will ultimately depend upon the individuals carrying out the work. There lies the greatest problem ; to that end must the utmost energy be especially directed.

CHAPTER XXVIII

FOOD HYGIENE IN THE HOME

It is obviously of modified value to ensure that foodstuffs are produced, handled or sold under hygienic conditions without giving at least brief consideration to the problems involved when food enters the home of the consumer. The knowledge possessed by the average member of the general public relating to food hygiene and food poisoning is apt to be sketchy, and is more often than not confined to reports of food-poisoning outbreaks and the like featured in the national or local press. In spite of increasing advice tendered to the general public, the ease with which food may become infected does not yet appear to have made any very lasting impression. It is certainly a fact that much good food is spoiled daily in homes throughout the country, and that the average housewife frequently neglects even the most elementary precautions necessary to safeguard the family health. The need for proper methods of handling food when it reaches domestic premises has always provided a very real problem, due in large measure to lack of knowledge on the part of those responsible for cooking, handling and serving food in the home.

It cannot, of course, be categorically stated that outbreaks of food poisoning begin in the home, except on comparatively rare occasions. Nor can it be claimed that deliberate irresponsibility on the part of the housewife is a potent factor in the problem. The housewife is usually only too anxious to avoid illness in the family. Unfortunately, as has already been stated, her knowledge of precautionary measures and her appreciation of the dangers which may arise are frequently of the scantiest order. It is therefore essential that these faults be corrected by every available means. Food poisoning in the home, although normally restricted in its power to spread, should be checked. It should be remembered that the familial type of food poisoning *can* be spread by case-to-case infection. An interesting example of this occurred in Southgate towards the latter part of 1950. Flexner (Type W) dysentery was imported into the district by a family which had recently returned from hop-picking in Kent. As so often happens with Flexner outbreaks, the disease spread rapidly to neighbouring families and relatives, although initially the members of only one family had shown any symptoms. One must therefore approach the problem of food hygiene in the home, recognising not only its possible effect upon an individual family, but also its wider and more serious potentialities.

No matter how interested the general public may be in food hygiene and the results of faulty methods, it is astounding how seldom they identify the principles and problems involved with what goes on in their own homes. Like the ostrich, they tend to bury their heads in the sands of complacency, apparently assuming that the housewife resembles Cæsar's wife in being above reproach. Unhappily, this is not always the case. The incidence of food poisoning in the home was exemplified by a limited survey recently carried out by one of the authors in Southgate. Following the death of an aged woman from food poisoning, and vague allegations that bread might be responsible, approximately 300 houses in the same road were visited. Inquiries were made as to how many members of each family had exhibited signs or symptoms of food poisoning during the previous four weeks. In just over 30 per cent. of cases at least one member of the families visited was stated to have shown such signs and/or symptoms. The road in question was good middle-class in character and, although the inquiries were made during August, the weather was by no means unduly warm. It was also noted that no particular foodstuff or food shop could be in any way blamed, while none of the sufferers appeared to have been implicated in a more extensive outbreak elsewhere.

The main varieties of food poisoning met with in the average home are salmonella, staphylococcus and indeterminate infections. Dysentery and other enteric infections may also occur. The home canning or bottling of food which has not been properly processed may cause botulism, although this is by no means a common phenomenon. Even allowing for the fact that botulism has an extremely grave prognosis, the possibility of its occurrence does not compare in importance with the less serious but more frequent types of infection. Custards, pastries, sauces and sliced cooked meats may provide a vehicle for staphylococcus infections. Salmonella infections may be due to salads, sliced cooked meats, custard-filled pastries, and may also be caused by the prevalent warming-up of left-over foods for future consumption, a practice which, in spite of existing shortages, has little to commend it. Danger from this source is especially liable to occur when the interval between initial use and future consumption is lengthy. Oysters, raw milk and other dairy products may be the source of typhoid cases, which may spread far beyond the confines of the family first affected ; while salads, raw milk, dairy products and the warming-up of left-overs may also be responsible for bacillary dysentery. Food accidentally contaminated by certain chemicals, such as lead, arsenic, the fluorides or antimony, may cause serious, although uncommon, illness, as will the consumption of poisonous fish or fungi, out-of-season mussels or rhubarb leaves. A number of foods may also affect individuals allergic to them, tinned fish and shell-fish being particularly implicated.

Small outbreaks of gastro-intestinal disturbances which occur in families are often collectively spoken of as attacks of diarrhœa, and are not usually reported to the affected person's medical attendant or to the responsible public health authority. Little thought is frequently given to such attacks, which are very often vaguely ascribed to the weather or to the depredations of that nebulous enemy "gastric 'flu," if indeed any attempt whatsoever is made to track down the source. It is only when a large number of people are affected, all of whom have partaken of food at one particular place and time, that any very great attention is paid to the matter. Thus, food poisoning following a party or wedding reception in the home becomes a tragedy ; anything less tends to be accepted as a natural hazard. The only way in which small family outbreaks are likely to become known is as a result of complaints made to the individual or firm who supplied the suspected food. In this connection it might be mentioned that, more often than not, the foodstuff blamed for the trouble was not, in fact, responsible. Indeed, in a high percentage of cases the responsibility for food poisoning contracted in the home must be ascribed to poor methods of handling or storage, and not to any outside source. When complaints are transmitted by a retailer to the producer, an investigation is usually carried out, mostly by the public health authority concerned. So much time usually elapses between the illness and the investigation that it is often extremely difficult, if not impossible, to determine the causative agent. Again, owing to the widespread belief that food poisoning is caused by what are popularly known as " ptomaines," tinned goods are very often suspected as being the cause of illness. In actual fact, as has already been pointed out, such foodstuffs are seldom implicated, provided they have been manufactured by a reputable firm.

Food or drink can readily become infected in the home in a variety of ways. Dirty hands used in handling the food, fingers with uncovered cuts or sores or, what is equally reprehensible, cuts and the like covered with slovenly bandages, can all add their quota of pathogenic organisms to food and drink. Germs from the nose or throat, especially the ubiquitous staphylococcus, may be ejected on to foodstuffs following uncontrolled sneezing or coughing. Dirty crockery, cutlery or cooking utensils can be dangerous, although contamination must usually be gross before serious harm can result. It is also important to remember that the use of dirty drying cloths may invalidate all the work of washing up. To the average, careful housewife any suggestion that her methods of washing utensils may not be entirely satisfactory savours of sacrilege, more especially if the advice emanates from the unfortunate husband. Yet it is a fact that, with a small sink, a mass of utensils, and the average quantity of luke-warm water usually available in the home, little effective cleansing and virtually no sterilisation is carried out. Added to this, the use of one cloth, which is often only replaced at weekly intervals, assists in re-infecting those utensils which may possibly have received a reasonably adequate wash. It is perhaps unfortunate that housewives cannot all be shown the number and variety of organisms grown by culturing swabs or rinses obtained from kitchen cloths. They might then more readily appreciate the dangers involved.

When crockery or other utensils are being washed, the milk bottle should never be overlooked. This humble article is too often forgotten. Even when it receives consideration, it is rarely given a thorough wash, but is only perfunctorily rinsed before being placed on the doorstep. Although the vast majority of milk bottles are machine-washed before they are used again, instances are increasing of inefficient treatment, due largely to inexperienced staff. For this reason the cleansing of milk bottles in the home is highly desirable, not only as a means of facilitating cleansing in the dairy premises, but also as an additional and very real safeguard. Milk bottles should *always* be properly washed before they are returned to the roundsman, and should never be allowed to stand on the doorstep over-night at the mercy of prowling animals. Schools might be pressed to take immediate steps to inculcate into their scholars the need for bottle-washing in the home. This advice might profitably be tendered after each milk session. School milk bottles are often among the dirtiest containers returned to the dairy, a fact which scarcely holds out maximum hope for the future.

The hands of those persons preparing or in any way handling food in the home should be kept clean at all times. How often does one see the housewife leave her work of preparing or cooking a meal to stroke the cat, replenish the fire, wash a few odds and ends in the sink, or carry out one of the multitudinous chores which fall to her lot ? Were she to wash her hands thoroughly after each one of these operations, little or no harm would probably be done. All too frequently, however, she fails to realise the importance of this simple ritual. Indeed, if the omission were pointed out, she would probably claim that she was too busy to concern herself with such trivial details. The routine washing of the hands following the use of the w.c. represents another frequent omission which must at all costs be remedied. Children should be taught the practice and required to carry it out as a matter of strict routine from the earliest age, so that the habit may become indelibly implanted in their minds and accepted as readily as retiring to bed at night or rising in the morning.

More care in the washing of crockery and cutlery is also required. Too much use is made of a quick rinse under the tap or a transient dip into lukewarm water, followed by drying with a soiled cloth. It is essential that the water used for this purpose be as hot as can be borne by the hands, while adequate soap or a suitable washing powder should be used in addition. Detergents or washing powders are virtually essential. They not only assist in the removal of grease or other materials adhering to the surfaces of the utensils ; they soften the water and prevent the formation of a scum on its surface, some of which is likely to adhere to the utensils and remain attached if the articles concerned are not properly rinsed or wiped. After a thorough washing, the utensils should be rinsed with very hot water and allowed to dry off naturally by the heat which they have absorbed from the water. It is probably too much to hope that the housewife will readily forsake her kitchen cloth. It is therefore important that several such cloths should be available, and that they should be frequently changed and washed.

Food preparation involves the risks of cuts, sores, scalds or burns contracted by handling kitchen knives or dealing with ovens. Such affections may become breeding places for pathogenic organisms, which may thereafter gain entrance to food during preparation. Any such conditions should be dealt with promptly, which points to the need for a first-aid box or cabinet in every house. It must also be borne in mind that a dirty bandage is a menace as well as an eyesore. Cuts and the like should be protected by means of an elastoplast or new-skin dressing, which should in turn be covered by a rubber finger-stall. These should be changed as occasion demands, the wound being covered until healing is complete.

All foods prepared in the home should be wholesome. As already mentioned, certain foods are more liable to cause food poisoning than are others. It is also an established fact that greater care is necessary in this respect during the summer months, when food-poisoning outbreaks are much more likely to occur. Special precautions are therefore necessary at such times. Any food which has a peculiar odour, which appears in any way abnormal or, in the case of canned goods, where the cans are of unusual shape, should be discarded. Left-overs should be closely watched ; the practice of leaving such foods for several days standing unprotected in the normal kitchen or food store is an invitation to disaster. When left-overs have to be eaten, they should be used quickly, and protected during the interim period from all sources of contamination.

It must, of course, be remembered that the most dangerously contaminated foods are often those which appear, smell and taste quite normal. The case of the Belgian sanitary inspector who offered to eat a sausage because he was convinced, in the absence of signs to the contrary, that it was all right, and who was dead in three days, is no myth. Appearances can be disastrously deceptive. Pathogenic bacteria—more especially those responsible for food poisoning—do not usually advertise their presence. This fact must be borne home to the housewife, lest she be lulled into a sense of false security for which she and her family may dearly pay.

To minimise the risk of bacterial growth, food should be kept as cool as possible during storage. This applies particularly to cooked dishes such as brawn, meat pies, sausages, milk, and also to reconstituted dishes such as custards and dried eggs. In connection with the last-mentioned articles, it is important that these should not be reconstituted for any length of time before being cooked and eaten. As noted elsewhere (see Chapter IV), reconstitution adds the moisture essential to bacterial multiplication. A refrigerator is the most suitable means available for the storage of food. Many modern houses, including council houses, are now being provided with this essential adjunct to hygienic food preservation. Refrigerators are no longer a luxury ; they are a necessity and, as such, should be exempt from purchase tax. A cool food store or larder is another essential part of the average house. Unfortunately, too many householders still have to rely on a small cupboard beneath the stairs, or one which is closely adjacent to the kitchen fireplace. Worse still, the prevailing housing shortage has caused the sub-letting of premises, often to several families, whose living accommodation is devoid of any form of food storage, suitable or otherwise. In such cases a suitable, ventilated cupboard should be affixed to a shady or north wall, although care must be taken to ensure that the food is not likely to be contaminated by dust or by domestic animals. Such food cabinets should be securely fixed above ground level. While by no means as satisfactory as a refrigerator or cool pantry, the food is at least given a reasonable chance of remaining wholesome and safe until consumed.

Food awaiting consumption should be protected from *flies* and *rodents*. Flies feed on filth and will carry dangerous organisms from their breeding and feeding grounds to any food upon which they may alight. They regurgitate or defæcate on food because of their inability to deal with solid food, rubbing the mass together with their feet. The result can be readily imagined. Similarly, the pollution of food by excreta left behind by rodents such as rats and mice can be the cause of virulent infection. All possible steps must therefore be taken to exterminate rodents infesting household premises, as well as any flies which may gain entrance. The breeding places of flies demand special attention, notably the domestic dustbin, more particularly during the fly-breeding season, normally late in July and early August, although this period may be appreciably extended. Food scraps should never be placed in dustbins, but should be burnt. The dustbin should be used only for dry matter, and should be provided with a tightly-fitting cover, which should always be kept in position. Particular attention should be paid to pig bins supplied by local authorities for the collection of waste foodstuffs. If fly or rodent infestations persist, the advice of the local public health department should be sought. Such advice will be willingly given, and should never be ignored. The part which domestic pets can play in the transmission of disease caused by food, particularly salmonella infections, has already been mentioned.

In order to avoid unnecessary risk, the housewife must make certain that adequate precautions are taken in regard to food which is to be consumed in the home. It is also vitally important that these precautions be rigorously maintained at all times. Children could profitably be educated by simple demonstration and example in the home as to the need for care in handling food. Food shops in which conditions are obviously unsatisfactory should not be patronised ; any faults noted should be reported to the local public health authority. Food shops should be told that any food delivered must not be left upon the doorstep, but that it should be placed in a bag or other container made available for the purpose. In this connection, the practice recently instituted by at least one local authority of issuing covered containers for milk bottles to householders might with profit be extended. In all cases, advice is freely available from the local medical officer of health or sanitary inspector in regard to recommended measures of food hygiene. Just as those engaged in the preparation and distribution of food are expected to be cleanly in their methods, so should the housewife continue the work without abatement. In this way, and in this way alone, can the quality of the food purchased be maintained, and the risk of untoward happenings diminished.

CHAPTER XXIX

EDUCATION AND FOOD HYGIENE

THE part which education should play in promoting a higher standard of conduct and method among those concerned in the preparation, handling or serving of food has been stressed many times in this volume. This has been done deliberately, as the future, so far as food hygiene is concerned, depends in very large measure upon the policy of education which is pursued.

In any programme of education dealing with food hygiene, attention must be specifically directed to three main groups : the general public, the staff whose duty it is to exercise control, and food handlers. Although the latter group is almost certainly the most important, the first two groups demand serious consideration, and must never be overlooked.

General Public

Although the safety of our food supplies depends to a very great extent upon those engaged in the food industry, the general public, particularly the housewife, has an important role to play. Food which was properly dealt with during its preparation, transit, storage and sale may very easily become contaminated after it has reached the home. Education of the general public is also required from another standpoint. What might be described as residual contamination can only be avoided by proper methods in the home. These methods categorically depend upon possession of the requisite knowledge by those concerned. Members of the public should be able to appreciate the factors which determine safety or danger, and be able to exercise their own judgment on matters which intimately concern their welfare and the health of their families.

Education of the general public may be undertaken in the following ways :

(*a*) *By talks, film shows, film strips or demonstrations given to local organisations, particularly women's organisations.* This type of health education can be extremely useful, especially if the talk is made interesting, and if it is accompanied by a sound film or suitable film strip. The sound film " Another Case of Food Poisoning " finds ready favour with most audiences, and is an excellent vehicle for promoting discussion. The more recent sound cartoon film " Fly About the House " is not quite so satisfactory, its message, although significant, being scarcely adequate to hold the attention of an audience throughout the film. A further fault lies in the fact that the message is not in all respects entirely clear.

Whenever talks of this nature are arranged, it is important to leave sufficient time for questions. There are very few topics in the field of health education which lend themselves to questions more fully than does food hygiene. Maximum advantage should be taken of this fact. Indeed, it would not be too much to say that most benefit is to be expected during the period devoted to questions. Where applicable, the system of group discussion can be adopted. When this method of approach is employed, the use of a magnetic blackboard or flannelgraph will be an advantage.

It is sometimes useful to concentrate on food hygiene during a winter programme of talks and/or film shows. Not only does this ensure the benefit of a concentrated attack ; it permits the lecturer to gauge more accurately the type of material best suited to his or her audience, and the reactions thereto. When it is remembered that the lecturer is usually a member of a public health staff and not a trained speaker, this point assumes added significance.

Simple *demonstrations* can be easily arranged to accompany talks and/or film shows. The materials to be included in such demonstrations can be prepared in any public health department, and should cover elementary precautions in the storage and serving of food in the home, among other topics. Where desirable, the assistance of the laboratory service covering the district can be sought in preparing suitable material for demonstrations. This co-operation will invariably be available, and should always be accepted where the type of audience is such that visual demonstrations of the kind prepared in a laboratory will be of obvious value.

The Central Public Health Laboratory Service is particularly helpful in this direction, and has available a wide selection of attractive, topical material which is loaned free of charge on request. The laboratory staff is also prepared to assist personally, either in the giving of lectures or in the preparation and supervision of visual demonstrations.

(*b*) *By talks, again accompanied where necessary by films or film strips, in schools.* As noted elsewhere in this volume, health education relating to food hygiene should commence at the earliest possible age. School children are interested in food, and will readily accept a film such as " Another Case of Food Poisoning," or a suitable film strip. Demonstrations can also be arranged, although these of necessity must be simple in character. Periodic visits to the school canteen are also useful. In some schools the senior pupils manage a self-contained flat in rotation. If such a flat is available, useful education in food hygiene can be provided on the spot.

(*c*) *By the holding of food hygiene exhibitions.* In order to stimulate interest, particularly in the early stages of a local campaign dealing with food hygiene, the holding of a *Clean Food Exhibition* is to be recommended. Here again the laboratory service can provide useful and attractive exhibits, as can the local maternity and child welfare services in the case of infant hygiene. In addition to other exhibition material, the Central Council for Health Education has now available the stand which was exhibited at the 1950 Food Fair at Olympia. This stand provides an excellent centre-piece for a food hygiene exhibition and can be hired at very low cost, the cost varying according to the distance which the stand has to be transported. The Ministry of Health has sponsored a portable exhibition set dealing with food hygiene. The theme of this three-unit set, which was produced for the Ministry of Health by the Central Office of Information, and which was also on show at the 1950 Food Fair at Olympia, is " Wash Your Hands before preparing Food." Its message is mainly directed to the housewife and food handler. The set is easily packed and handled, and can be obtained on loan on payment of the appropriate transport charges. The Ministry of Food also has available certain very attractive exhibition material, while the Ministry of Agriculture and Fisheries (Infestation Control Division) has been of the greatest practical assistance in designing, arranging and supplying material for Clean Food Exhibitions.

One other point in connection with such exhibitions appears worthy of special mention. If a café or canteen is operated in connection with an exhibition of this character, the strictest care should be taken to ensure that the standard of hygiene is of the highest possible quality. Unfortunately, this is not always the case !

Dr. F. R. O'Shiel, Medical Officer of Health to the Metropolitan Borough of Stepney, recently conducted a most interesting experiment in relation to a clean food campaign. Knowing only too well that many people will not take the trouble to visit an exhibition held indoors, he decided to take the material to his public in the streets and open spaces. This material included a mobile cinema van, leaflets, posters, charts, bacteriological exhibits and models. A mobile information van accompanied the rest of the exhibition, and relayed an interesting talk given by Dr. O'Shiel. Discussion was encouraged after the film show, and it is interesting to note that members of the Public Health Department staff were briefed to ask questions, in order to promote a stimulating discussion. Full civic recognition was accorded by the presence of the Mayor and Mayoress at working sessions. Dr. O'Shiel's report states that approximately 6,000 people are estimated to have attended the various sessions held. The further suggestion is made that the extent of any one session should not be as long as two hours, as in the original experiment. Cutting down of the time occupied by a session would permit of more ground being covered. The Stepney experiment seems to be one which might be copied with advantage by other local authorities, particularly those responsible for rural areas.

It should also be remembered that any food hygiene exhibition or clean food campaign should only be regarded in the nature of a stimulus. It should form part of a co-ordinated campaign, which must be continuous. If this point is neglected, much of the usefulness of such a campaign will be dissipated.

(*d*) *By articles in the local press.* Articles on food hygiene will be accepted by most local newspapers, and form a useful medium for the dissemination of topical knowledge. If possible, such articles should appear from time to time, linking up with any campaign which is then in progress. The articles should be simple. Whenever possible, they should deal with only one aspect of the problem. If too much ground is covered in any one article, the value of the article may easily be dissipated.

(*e*) *By the display of suitable posters and the distribution of leaflets.* Attractive posters and stickers dealing with food hygiene are available from the Central Council for Health Education at moderate cost. Various leaflets are similarly available. The Food Hygiene Section of the Ministry of Food also has available a certain amount of literature and some excellent posters. The Nutrition Section of the Ministry of Food can provide further material. Health offices, libraries and infant welfare centres furnish useful sites for the display of posters and for the distribution of leaflets, while public sites should also be used. Quite recently, the Ministry of Food has offered their local food offices for the same purpose. The value of a local food office, as a means of establishing contact with substantial numbers of the general public immediately interested in food, will be obvious.

Although it is doubtful whether leaflets or booklets dealing with health education always arrive in the right place, this medium can be used as an adjunct to any other propaganda methods employed.

(*f*) *By use of the B.B.C.* The B.B.C., notably through its " Women's Hour " programme, can sometimes be persuaded to co-operate in local campaigns designed to appeal to the general public. To the radio must now be added the almost limitless potentialities of television.

Care must be taken in any campaign directed towards the general public to avoid giving the impression that existing conditions are deplorable. Exaggeration, however picturesque, must at all costs be resisted ; alarmist statements must be rigorously omitted. As has been well stated by Dr. C. F. Whyte, the housewife cannot be expected, and should never be advised, to achieve the standards of the operating theatre in her kitchen ; to suggest that she should do so would merely invite ridicule. A common-sense approach must always be maintained. The lay public is not always so lacking in knowledge as many so-called experts would have us believe. The main objects in health education of members of the general public, so far as food hygiene is concerned should be to fill the gaps in their knowledge, correct any false impressions which may have been created in their minds, and direct their thoughts into the proper channels.

As already indicated, it is essential that the public should be taught not only the methods of safeguarding food in the home, but also the points to watch in connection with food establishments of all kinds. The knowledge possessed by members of the general public regarding matters which affect their welfare can indeed be sketchy, resembling nothing so much as a patchwork quilt ; in no field is this more apparent than in that of food hygiene. In approaching members of the general public, it is vitally important to seek their co-operation. They should be told that they form a really important part of the team, and made to feel that their co-operation is not only desired but extremely valuable. They should be asked to avoid food establishments in which the standard of hygiene leaves anything to be desired. They should also be invited to let the local authority know of any conditions detrimental to health which come to their notice. Only by making members of the general public appreciate the importance of the problem, and the significant part which they themselves have to play, can success be expected. The effort brought to this task is very well worth while. A community which is made properly aware of the problem and of its individual and collective responsibilities will almost invariably respond. This co-operation should be looked upon as the first step in any campaign which has food hygiene as its object.

Staff engaged in Control

Until it is the rule to appoint specially trained officers to deal with food hygiene, it remains a fact that most members of a public health department staff who are engaged in this type of work have not been specially trained for their important task. It is therefore essential that this omission be remedied so far as is practicable. In many parts of the country, the Central Public Health Laboratory Service has arranged excellent courses of instruction for sanitary inspectors and the like. Where such courses are available, arrangements should be made for every sanitary inspector on the staff of the local authority to attend. The Central Council for Health Education also arranges similar courses, which are of the very greatest value. One way or another, it is imperative that any member of a local authority staff who has the duty of inspecting food premises and giving advice, or who may be called upon to address a meeting on the subject of food hygiene, should be in a position to speak and to demonstrate with the fullest possible authority.

Under our present system, the sanitary inspector is the main educator, so far as food premises and food handlers are concerned. To ask a sanitary inspector to carry out these vital duties without an adequate background is to court disaster. It will not surely be suggested that a sanitary inspector's normal training, however excellent that may be, provides this necessary background. Even the medical officer of health—and certainly his medical staff—should not be forgotten. They themselves may require special training, if only in the difficult art of putting a message across. Too little attention has been paid in the past to educating the educator. Yet, without this essential safeguard, a great deal of useful energy may be misdirected. Exceptional brilliance or heights of oratory are not required and may even be a disadvantage. All that is wanted is sound knowledge of the various teaching techniques available, an even sounder knowledge of the problem and principles involved, and an honest desire to put that knowledge to the best possible use. Given the necessary opportunity, the sanitary inspector will match up to the standards required. He should be provided with that chance in every instance.

Food Handlers

The methods of approaching food handlers will naturally vary according to the type of community and the standards already in existence. None the less, the principles underlying this approach are more or less standardised, and warrant most serious consideration.

So far as the *local authority* is concerned, they might be itemised as follows :

(*a*) *Education supplied by the sanitary inspector during his periodic visits to food premises.* As already indicated, the sanitary inspector should be regarded as the prime source of information available to food handlers in his area. During his visits to food premises he should never miss an opportunity of supplying advice and guidance, whether or not this be specifically requested. He should endeavour by every practicable means to gain the confidence of the food handler, both employer and employee, and should be regarded not primarily as an enforcement officer, but rather as a friend and mentor who is always prepared to be of practical assistance. Much can be done in this way ; much should be done. Where necessary, of course, more stringent methods may have to be adopted, but it is always pleasing to observe how many difficulties can be overcome, and how many improvements effected, by the judicious application of tact, common sense and a friendly approach.

Just as the family doctor is the first line of defence and attack in the field of preventive medicine, and just as the health visitor is the keystone of health education in the clinic and in the home, so must the sanitary inspector be regarded as the pivotal point in any local programme of education in food hygiene directed towards the food handlers operating in his area.

(*b*) *The holding of meetings to which food handlers are invited.* Meetings of this nature can be of value. As in the case of the general public, however, they should only be regarded in the nature of a stimulus. The holding of a large public meeting, no matter how well attended, will have no lasting value if the meeting is not followed up by more continuous propaganda. None the less, a public meeting has its uses, provided it is made to take its proper place in a co-ordinated programme and is not regarded as an isolated phenomenon.

Wherever possible, meetings of food handlers should be accompanied by demonstrations calculated to arouse the interest of the audience. It is very often useful to hold such a meeting in a school canteen, and to arrange a practical demonstration in the kitchen of the canteen. Adequate time for questions should, of course, be allowed. A great deal of thought should go into the preparation of a meeting of food handlers. The programme must be meticulously arranged, the best available speakers chosen. Equal care should be paid to the demonstration and to the demonstrators. Only by most careful pre-planning can success be expected ; in attempting to improve the haphazard methods met with in certain sections of the food industry, it would indeed be dangerous to copy their unfortunate example.

(*c*) *Courses of instruction.* Courses of instruction for food handlers should be arranged, preferably in conjunction with the appropriate laboratory service, or by arrangement with the Central Council for Health Education. Such courses will vary in time and content, according to the type of food handler who attends. Once again it is useless—indeed extremely dangerous—to arrange such courses of instruction and then to let the matter drop. Where any courses of instruction are, in fact, arranged, these should be followed up by refresher courses and by other methods of health education. The Borough of Ealing has an excellent scheme of this nature in existence, operated by the public health staff. Five lectures are provided under the scheme. The first lecture is given to an audience of eighty to 100, and is supplied by a prominent bacteriologist, who outlines the principles of bacterial contamination. The class then sub-divides into groups of twenty to thirty for the succeeding lectures. So far as is possible, the various trades represented are kept in their own groups, the talks being adapted to their particular needs. Special lectures are also arranged for members of the milk industry, and for bakers and confectioners. It is stated that the concluding session—on the legal aspects of food trading—has proved surprisingly popular. Up to the end of December, 1951, 188 lectures had been given to food handlers with the issue of 887 certificates for full attendance. Use was made during the course of blackboard illustrations, bacterial demonstrations, film strips and films. In addition, 33 lectures had been given to 1,400 children about to leave school.

The scheme adopted by Ealing formed part of a long-term, adequately-planned clean food campaign. The campaign was inaugurated by an ambitious food exhibition, which attracted 8,000 people in one week. It comprises a detailed system of inspection and recording, the granting of certificates of hygiene, lectures, talks in schools, the issue of metal notices for display in sanitary conveniences, and the preparation of an attractive illustrated handbook for distribution to food premises. The Ealing scheme has much to commend it, and will surely repay future study.

(*d*) *The display of posters, stickers and metal notices in food premises.* The display of posters, stickers and metal notices in food premises, although a useful feature of health education, should only be considered as a comparatively minor adjunct to any programme as a whole. Where such methods are adopted, it is essential that the means of following the advice supplied are readily available. Thus, it is dangerous in the extreme to exhibit notices calling for employees to wash their hands after using the w.c., if the necessary facilities are not easily procurable. Such action will merely produce a feeling of annoyance, if not untimely humour, and may very seriously affect the value of any health education programme which happens to be in progress.

The Central Council for Health Education has produced some excellent material for use in food premises, notably various drawings by the artist Fougasse. These are humorously attractive but still contrive to convey their message simply and to advantage. Mention might also be made of the admirable plaque issued by the British Tourist and Holidays Board for display in cafés, restaurants and catering establishments generally.

(*e*) *The formation of Hygienic Food Traders' Guilds.* Many such guilds have recently been formed, following the lead given by the Borough of Guildford. Their constitution and mode of operation vary very considerably from place to place, although the principles underlying the scheme remain more or less the same. Broadly speaking, the objects of such guilds are to encourage food traders to promote within themselves a higher standard of hygiene. The sponsors of these guilds claim that, by encouraging food traders to raise their own standards by co-operative effort and a spirit of emulation, better results can be obtained than by the application of more standardised methods.

In most instances Hygienic Food Traders' Guilds have been inaugurated by the local authority, very often in conjunction with the local Chamber of Commerce. In some instances, officers of the local authority occupy important offices in the guild ; in other cases, the local government officers concerned act merely as advisers after the initial stages have been passed. Codes of Practice (see Appendix 1) are prepared, based upon the statutory requirements for the food trade concerned. A committee is formed, usually consisting of representatives of the various food trades operating in the area covered, and normally including members of the local Public Health Committee and Chamber of Commerce. A membership fee may be required.

The decision as to whether or not an application for membership of the guild should be accepted is governed by a report received from the appropriate sanitary inspector, this report being considered by the governing committee. A certificate is usually supplied to members of the guild for display in their premises. Where, as almost invariably happens, employees are admitted to membership, they are very often supplied with a badge. In some cases, members of the general public are invited to become members of Hygienic Food Traders' Guilds as consumer members. If the guild is what it claims to be, i.e. a banding together of food traders to improve their own standards, it is difficult to see how this latter policy can be justified.

Opinion still differs as to the usefulness of Hygienic Food Traders' Guilds. Some authorities hold that their activities cut across those of the local authority, and that the imposition of higher standards than those required by law presents a difficulty which outweighs the other and more obvious advantages of the guilds. The consensus of opinion, however, is that such guilds *do* fulfil a useful purpose, and that they achieve something which is seldom within the reach of the local authority. Where a Hygienic Food Traders' Guild is in operation, it should play an active part in educating the employees who are its members. Indeed, such educational activities can and should be extended to all food traders operating within the area covered by the guild. Thus, courses of instruction can be arranged, with periodic meetings and demonstrations, while use can be made of the local press to insert articles of topical interest.

If the proper approach is made, it would seem that Hygienic Food Traders' Guilds have a very definite part to play in almost any community. According due weight to all considerations, it would appear advisable that such guilds should operate side by side with the local authority, whose officers should be available at all times for advice and guidance, but should not hold actual office.

Large Commercial Undertakings

Health education in food hygiene should form an important part of the organisation of any large undertaking which deals in food. It is the duty of such undertakings to educate their own employees, and to take all possible steps to raise the standard of hygiene in their premises and among their staff. Where necessary, the assistance of the local authority can and should be requested, although it should normally be possible for a large organisation to undertake this work within its own sphere. Some commercial organisations, notably Messrs. Marks & Spencer Ltd., are already engaged in an active programme of health education, which is showing excellent results. The admirable booklet on food hygiene produced by Messrs. Marks & Spencer Ltd., together with the workmanlike film strip available for showing to employees, are outstanding examples of what can be done in this most important field. As an equally important corollary, the standards of hygiene rigorously maintained by this firm represent in themselves a potent factor in health education. The staffs of local authorities, notably sanitary inspectors, have very many duties to perform ; food hygiene is only one of their many responsibilities, which can claim merely a part of their time. It is therefore highly desirable that large organisations should undertake this work of their own volition, and that they should not call upon the assistance of the local authority except as advisers or unless they are invited to participate in a locally organised campaign. When such an invitation is extended, the co-operation of the larger organisation should be generous. There is no doubt that, if every large food-producing firm in the country were to embark on a really ambitious programme of health education, the results would be really significant. One would like to see this done as a matter of course and not as the comparatively rare exception.

As already indicated, education in one form or another remains our greatest hope for the future. Without education a true realisation of the problem and of the many and onerous responsibilities which rest with the food handler can never be achieved. The stupid mistake will always occur ; the unfortunate accident can never be eliminated. What we can and should do is to ensure that everyone in any way connected with food—and that means more or less the entire community—appreciates what he or she must do, and how it can be done. Here is a fruitful field whose limits reach well-nigh to infinity.

As already noted, health education of the food handler and of the general public is the province of the central authority, local authorities and large commercial undertakings. Expert assistance can, of course, be obtained from the Central Council for Health Education, from the laboratory service, and from other sources. Unless, however, the three bodies referred to above embrace the opportunities for health education which now present themselves, it is scarcely conceivable that substantial progress will be made. A lead should also be given to the country by the central authority. Local authorities, in turn, must give a lead to the areas which they cover. It must further be remembered that health education is very largely a matter of team-work. Isolated, sporadic efforts have little value ; the problem must be tackled as a whole with vigour, foresight and a thorough understanding of the diverse issues involved.

This points to the need for the most careful planning. A Clean Food Campaign should never, for instance, be embarked upon until the preliminary groundwork has been properly laid. This will save a great deal of time and misunderstanding. Although the principle of adequate planning has been well established, it is surprising how often its importance is forgotten. Local campaigns will, of course, vary according to the type of community to which they are directed. Whatever type of health education is undertaken, however great the effort or small the audience, pre-planning, co-ordination and team-work are essential to success.

CHAPTER XXX

THE FUTURE

HAVING regard to the conditions which still exist in too many of our food establishments, and to the urgent need for improvement in methods and outlook, the future so far as food hygiene is concerned is a subject of very great importance. Many individuals and bodies are bound up with this future in a variety of different ways. Application of the principles of food hygiene should be designed to ensure that food is delivered to the consumer in the best possible condition, both as regards cleanliness, safety and nutritional value. Everyone concerned with food in any way—and this includes the consumer—should be personally interested in the problem, and should be prepared to play his or her part in shaping the future. It cannot surely be denied that conditions have retrogressed since pre-war days. Although excuses may be found for the unhappy state in which we so often find ourselves to-day, it would be the height of folly to sit idly back and accept our difficulties as inevitable. We know that conditions exist which should not be tolerated. Scientific advances, particularly in the field of bacteriology, have given us the answer to many of our problems. It is no less than our duty to consider the whole field of food hygiene, and to see where and how necessary improvements can be effected.

The *central authority* should ask itself whether existing legislation is either sufficiently clear or sufficiently comprehensive to provide the powers necessary to raise existing standards. It is, unfortunately, a fact that present-day restrictions too often negative action which appears in every way desirable. This has been put forward as an excuse for postponing the extension of existing legislation, the statement being made that legislation which cannot be enforced is worse than useless. Although this line of thought is in some ways logical, adequate preparations must be made for the future. Few will deny that our present legislation is not wholly adequate, and that it is beset with inconsistencies. If we are to regain what has been lost and make still further progress, this gap must be closed. Our legislators should be fully prepared for the time when restrictions will end. Without a firm and definite lead from the central authority, success will still elude our grasp. This lead should be emphatic, and should provide the machinery and opportunities which everyone concerned with food hygiene so ardently desires.

The central authority should also be actively engaged in mapping out a comprehensive scheme of education. If it is agreed, as surely it must be agreed, that an adequate programme of education is a pre-requisite to improved standards, arrangements should be made as speedily as conditions will allow to bring this into effect. It should be made as easy as possible for those concerned in the arrangement of educational measures to take the necessary action ; they should be encouraged to do so and afforded all practicable help. The need for a clear and definite lead from the central authority will again be apparent.

It would also be of assistance to local authorities to receive from the central authority specific Codes of Practice for each type of food premises. A step in this direction has been taken by the issue of the Report of the Catering Trade Working Party, which, if implemented to the full, as it ought to be, should ensure considerable improvement of method and co-ordination of effort. At the moment local authorities which have sponsored Hygienic Food Traders' Guilds prepare their own Codes of Practice, which vary from place to place. This is, perhaps, not a vitally important point, as local variations, made with an accurate knowledge of local conditions and needs, can be advantageous. The preparation by the central authority of model Codes of Practice, with provision for the insertion of local variations, would, however, appear most desirable in the circumstances.

Local authorities are at present restricted in the volume of work which they can undertake. They should, none the less, continue to make the most of the opportunities provided, according due priority to food hygiene in their annual programmes. Unless and until special officers (food sanitarians) can be appointed to the staffs of local authorities, the onus will apparently continue to fall upon the sanitary inspector. He should receive special training in this important work, so that he can approach food handlers in the role of an expert, and speak with authority. This is essential to adequate progress.

The field of food hygiene, linked as closely as it is with the modern concept of epidemiology, presents a fruitful field for investigation and research. The situation in any community should be carefully studied by the local authority concerned. An accurate assessment should be made of urgent needs, and every possible attempt made to meet those needs. The important role which a local authority can play in the vital field of *health education* has already been stressed. There is little doubt that the local authority is, and always will be, the most important link in the chain of health education. If the local authority fails in its duty, it can scarcely be expected that any other body will be prepared to take its place. In this connection it should be remembered that the Central Council for Health Education, the Ministry of Health, the Ministry of Food, the Ministry of Agriculture and Fisheries, and the laboratory service are prepared to advise on any local campaign dealing with food hygiene. Whether or not this advice is sought, such campaigns are vitally important, and will undoubtedly affect the future of food hygiene in any area. It cannot be too often emphasised that such campaigns must be continuous, and that they should be carefully planned. They may be reinforced from time to time with special efforts, but the work of health education so far as the food handler is concerned, not forgetting the general public, must never cease. Here lies the answer to many of our problems ; here rests our most encouraging hope for the future.

When considering the adoption of a planned campaign designed to improve standards of food hygiene in their areas, local authorities might be well advised to incorporate into the agreed programme a short-term and long-term policy. The *short-term policy* should deal with immediate day-to-day requirements, having due regard to existing conditions. The *long-term policy* should take into consideration future policy, with particular reference to education. It cannot be too frequently stressed that conditions must never be allowed to become static. Too much is at stake ; the penalties attaching to complacency and a policy of *laissez-faire* are more than we can carry. *A continuous policy of attack is imperative.* What form this attack shall take may vary, but it must be supported.

Commercial undertakings concerned with the manufacture, preparation, storage, handling or sale of food also have an important part to play. The smaller firms, particularly cafés, restaurants and food shops, will tend to look to the local authority for a lead. Only rarely will they reach and maintain an adequate standard by their own unsupported effort. This lead must be supplied by the local authority, by way of advice, courses of instruction and personal supervision. In this connection, the role of Hygienic Food Traders' Guilds has already received attention, as has the comprehensive programme adopted by such authorities as the Borough of Ealing.

The larger commercial undertakings should be persuaded to build up their own hygienic organisations. They should be made to understand that it is in their own interests to take this action, quite apart from the effect upon the health and well-being of the general public. No one can doubt that, if such a policy were to become universal, the standard of food hygiene would be improved. It is encouraging to note that the courses available to those seeking to enter the catering world are now stressing more and more the value of food hygiene as a practical solution to many of our problems. This will undoubtedly have its effect in time, and is a policy to be encouraged.

Any plan embracing the future of food hygiene must not lose sight of the part which the *general public* has to play. As usual in this country, the man in the street, although he is the prime sufferer at the hands of the careless or ignorant food handler, devotes very little thought to the matter, and then only when things go wrong. Public opinion must be aroused to demand an improvement in existing conditions. This end can best be achieved by educating the public in the comparatively simple rules which govern food hygiene, so that our citizens may appreciate the dangers which can arise and the preventive measures which should be taken. Members of the general public form a definite part of the team ; if they pull their weight the results can be substantial.

The local authority has again an important role to play in this aspect of the problem. Any local campaign designed to improve existing standards of food hygiene should always include the public. Psychologically, this is a sound principle. Not only is the public thus made aware of its responsibilities and asked to co-operate ; the food trade will also realise that others are being invited to play their part and to share the burden. Team-work is essential to success ; the more the members of the team work together, the better and quicker will improvements be effected.

The time has long passed when we can afford to adopt a short-term policy designed to meet the needs only of the day. The whole position must be carefully studied, having regard to all its implications. Efforts must be co-ordinated, not only in each locality but throughout the country as a whole. The downward trend must be halted before anything approaching disaster overtakes us. It is perhaps not too much to say that we stand at the cross-roads. We have the knowledge, or at least the essential knowledge ; we know where the faults lie, and we should know how to correct them. In a country which boasts a National Health Service it is surely intolerable to allow conditions to be perpetuated which jeopardise the safety of its population. The future is very definitely at stake and must be properly safeguarded.

APPENDIX 1

THE Codes of Practice applicable to various retail food trades have already been mentioned on pp. 416 and 455, where consideration was given to the formation of Hygienic Food Traders' Guilds. The originators of this system of food control, the Guildford Borough Council, produced a number of Codes of Practice, which have formed the basis of similar action by other local authorities. They are set down in the succeeding pages by kind permission of Dr. F. A. Belam, Medical Officer of Health for Guildford, and the Guildford Hygienic Food Traders' Guild.

BOROUGH OF GUILDFORD

BAKEHOUSES AND CONFECTIONERS—CODE OF PRACTICE

Standards to be maintained for Membership of the Guildford Hygienic Food Traders' Guild

1. The walls, ceilings, floors, windows and doors of every bakehouse, flour store, bread store or shop wherein food is prepared, stored or distributed shall be kept in a proper state of repair so as to maintain a high standard of cleanliness.

2. The walls, ceiling, window-frames and doors shall be painted and redecorated as often as may be necessary, and at least once in every month shall be so washed or cleansed as to maintain the premises in a clean condition ; and the windows shall be kept clean at all times.

3. There shall be adequate natural and/or artificial light to enable the various processes to be carried out in a hygienic manner.

4. There shall be provided adequate means of ventilation, preferably from the open air, and sufficient ventilation shall be maintained.

5. No refuse or filth, whether solid or liquid, shall be deposited or allowed to accumulate on or about the premises, and all floors, yards and passages shall be kept clean. A sufficient number of covered receptacles shall be provided and maintained for trade and other refuse.

6. All equipment, including storage and mixing receptacles, trays and shop fittings, shall be thoroughly cleansed and maintained in a clean condition. Delivery vans and baskets shall be thoroughly scrubbed and cleansed at least once weekly.

7. There shall be provided in a readily accessible position, and, if possible, adjacent to sanitary accommodation, a sufficient number of fitted wash-basins or sinks, provided with a constant supply of hot and cold water. There shall also be provided adequate supplies of clean towels, soap and nail-brushes for the use of persons employed.

8. Adequate sanitary accommodation, separate for the sexes, shall be provided and maintained in a clean condition.

9. No sanitary accommodation or dustbin shall be within or communicate directly with the rooms, or be so placed that offensive odours therefrom can penetrate into the rooms.

10. No cistern for the supply of water to the rooms shall be in direct communication with, or discharge directly into a sanitary convenience, and there shall not be within the room any outlet for the ventilation of a drain or any inlet into any soil water drain.

11. All foodstuffs to be protected from contamination by dust, dirt, flies, etc., and for this purpose protection to open displays of goods must be provided by suitable coverings. A suitable place, provided with adequate protection from contamination, shall also be provided for bread and confectionery during the period of cooling and storage.

12. In the case of ovens in which solid fuel is used, no fuelling shall be carried on within the bakehouse and no stocks of fuel for this purpose shall be stored there, except where such an arrangement would be impracticable from a structural point of view ; in such cases sufficient fuel for one day's supply shall be stored in a covered receptacle (e.g. coal bunker), and such receptacle shall not be refilled whilst baking processes are in progress.

13. Members of the Guild will ensure that all foodstuffs sold are clean, fresh and in all respects fit for human consumption.

14. The premises shall at all times be kept free from infestation by rats, mice, beetles, flies and any other vermin and/or insects, and in the event of any such infestation arising immediate action will be taken for treatment through the Local Authority or otherwise.

15. Personal clothing of employees not worn whilst working must not be kept in a room where food is being prepared, stored or sold, except in a cupboard provided for the purpose.

16. Employers shall take reasonable precautions to ascertain if any of their staff are suffering from or have been in contact with any infectious or contagious disease, and should any such case occur the employer shall immediately notify the Medical Officer of Health.

17. Employers shall, having provided all reasonable facilities for the personal cleanliness of employees, encourage and, as far as possible, ensure that all persons employed in the preparation, distribution and handling of foodstuffs on their premises comply with the rules relating to employees.

18. A copy of this Code of Practice shall be exhibited on the premises for the information of all concerned in the handling or distribution of food.

The conditions contained in this Code are without prejudice to any statutory requirements that may from time to time be in force.

EMPLOYEES

1. Employees must see that a high standard of personal cleanliness is maintained, e.g. :—

(*a*) Hands and finger-nails should be scrubbed clean before commencing work, and after every visit to a sanitary convenience, and as often as necessary.

(*b*) Persons engaged in the preparation of foodstuffs must wear a suitable head covering.

(*c*) Overalls must be changed as frequently as necessary to maintain a clean appearance.

(*d*) Smoking during the preparation, handling and distribution of foodstuffs is prohibited.

2. Premises, fixtures, fittings, etc., for which the individual employee is responsible must be kept clean at all times. Delivery vans and baskets shall be thoroughly scrubbed and cleansed at least once weekly.

3. In so far as present conditions allow food must be wrapped in clean hygienic wrappers, and wherever possible a clean new inner wrapping should be used in addition to any newspaper which may be used.

4. Employees must undertake to do everything possible to support the

efforts of employers in preparing, handling and distributing food in a thoroughly clean and hygienic manner.

5. Employees must immediately notify their employer if suffering from or in contact with an infectious or contagious disease.

BUTCHERS—CODE OF PRACTICE

Standards to be maintained for Membership of the Guildford Hygienic Food Traders' Guild

1. The walls, ceilings, floors, windows and doors of every shop, store, room and refrigerator wherein food is prepared, stored or distributed shall be kept in a proper state of repair so as to maintain a high standard of cleanliness.

2. The walls, ceilings, window-frames and doors shall be painted and redecorated as often as may be necessary, and at least once in every three months shall be so washed or cleansed as to maintain the premises in a clean condition ; and the windows shall be kept clean at all times.

3. There shall be adequate natural and/or artificial light to enable the various processes to be carried out in a hygienic manner.

4. There shall be provided adequate means of ventilation, preferably from the open air, and sufficient ventilation shall be maintained.

5. No refuse or filth, whether solid or liquid, shall be deposited or allowed to accumulate on or about the premises, and all floors, yards and passages shall be kept clean. A sufficient number of covered receptacles shall be provided and maintained for trade and other refuse.

6. All equipment, including storage receptacles, trays, shop fittings and vehicles shall be thoroughly cleansed and maintained in a clean condition.

7. There shall be provided in a readily accessible position, and if possible adjacent to sanitary accommodation, a sufficient number of fitted wash-basins or sinks provided with a constant supply of hot and cold water. There shall also be provided adequate supplies of clean towels, soap and nail-brushes for the use of persons employed.

8. Adequate sanitary accommodation, separate for the sexes, shall be provided and maintained in a clean condition.

9. No sanitary accommodation or dustbin shall be within or communicate directly with the rooms, or be so placed that offensive odours therefrom can penetrate into the rooms.

10. No cistern for the supply of water to the rooms shall be in direct communication with or discharge directly into a sanitary convenience, and there shall not be within the rooms any outlet for the ventilation of a drain or any inlet into any soil water drain.

11. All butchers' shops must be provided with a closed window at the front of the premises, and suitable protection must be provided in every part of the premises where meat is displayed or stored, and where contamination by dust, dirt, flies, etc., is likely to arise.

12. In so far as present conditions allow, meat must be wrapped in a clean hygienic wrapper and, wherever possible, a clean new inner wrapping should be used in addition to any newspaper which may be used.

13. Members of the Guild will ensure that all meat sold is clean, fresh and in all respects fit for human consumption.

14. The premises shall at all times be kept free from infestation by rats, mice, beetles, flies and any other vermin and/or insects, and in the event of

any such infestation arising immediate action will be taken for treatment through the Local Authority or otherwise.

15. Employers shall take reasonable precautions to ascertain if any of their staff are suffering from, or have been in contact with, any infectious or contagious disease, and should any such case occur the employer shall immediately notify the Medical Officer of Health.

16. Employers shall provide all persons engaged in the handling of meat in bulk with a clean washable head covering and overall.

17. Personal clothing of employees not worn whilst working must not be kept in a room where food is being prepared, stored or sold, except in a cupboard provided for the purpose.

18. Employers shall, having provided all reasonable facilities for the personal cleanliness of employees, encourage and as far as possible ensure that all persons employed in the preparation, distribution and handling of meat on their premises comply with the rules relating to employees.

19. A copy of this Code of Practice shall be exhibited on the premises for the information of all concerned in the handling or distribution of food.

The conditions contained in this Code are without prejudice to any statutory requirements that may from time to time be in force.

EMPLOYEES

1. Employees must see that a high standard of personal cleanliness is maintained in regard to :—

(*a*) Hands and finger-nails should be scrubbed clean before commencing work, and after every visit to a sanitary convenience, and as often as necessary.

(*b*) Persons engaged in the handling of meat in bulk must wear suitable clean head covering.

(*c*) Overalls must be changed as frequently as necessary to maintain a clean appearance.

(*d*) Smoking during the preparation, handling and distribution of meat is prohibited.

2. Premises, fixtures, fittings, etc., including vehicles, for which the individual employee is responsible must be kept clean at all times.

3. Employees must undertake to do everything possible to support the efforts of employers in preparing, handling and distributing food in a thoroughly clean and hygienic manner.

4. Employees must immediately notify their employer if suffering from or in contact with an infectious or contagious disease.

CAFÉS AND RESTAURANTS—CODE OF PRACTICE

Standards to be maintained for Membership of the Guildford Hygienic Food Traders' Guild

1. The walls, ceilings, floors, windows and doors of every café, restaurant, kitchen, servery and store wherein food is prepared, stored or distributed shall be kept in a proper state of repair so as to maintain a high standard of cleanliness.

2. The walls, ceilings, window-frames and doors shall be painted and redecorated as often as may be necessary, and at least once in every three months shall be so washed or cleansed as to maintain the premises in a clean condition ; and the windows shall be kept clean at all times.

3. There shall be adequate natural and/or artificial light to enable the various processes to be carried out in a hygienic manner.

4. There shall be provided adequate means of ventilation, preferably from the open air, and sufficient ventilation shall be maintained.

5. No refuse or filth, whether solid or liquid, shall be deposited or allowed to accumulate on or about the premises, and all floors, yards and passages shall be kept clean. A sufficient number of covered receptacles shall be provided and maintained for trade and other refuse.

6. All equipment, including crockery, cutlery, storage receptacles, trays and fittings shall be thoroughly cleansed and maintained in a clean condition.

7. There shall be provided in a readily accessible position, and, if possible, adjacent to sanitary accommodation, a sufficient number of fitted wash-basins or sinks provided with a constant supply of hot and cold water. There shall also be provided adequate supplies of clean towels, soap and nail-brushes for the use of persons employed.

8. Adequate sanitary accommodation, separate for the sexes, shall be provided for employees and customers, which shall be maintained in a clean condition.

9. No sanitary accommodation or dustbin shall be within or communicate directly with the rooms or be so placed that offensive odours therefrom can penetrate into the rooms.

10. No cistern for the supply of water to the rooms shall be in direct communication with or discharge directly into a sanitary convenience, and there shall not be within the room any outlet for the ventilation of a drain or any inlet into any soil water drain.

11. All foodstuffs must be protected from contamination by dust, dirt, flies, etc., and for this purpose protection to open displays of goods must be provided by suitable coverings.

12. All personal clothing of employees not worn whilst working must not be kept in a room where food is being prepared, stored or sold, except in a cupboard provided for the purpose.

13. Members of the Guild will ensure that all foodstuffs sold are clean, fresh and in all respects fit for human consumption.

14. The premises shall at all times be kept free from infestation by rats, mice, beetles, flies and any other vermin and/or insects, and in the event of any such infestation arising immediate action will be taken for treatment through the Local Authority or otherwise.

15. Employers shall take reasonable precautions to ascertain if any of their staff are suffering from or have been in contact with any infectious or contagious disease, and should any such case occur the employer shall immediately notify the Medical Officer of Health.

16. Employers shall, having provided all reasonable facilities for the personal cleanliness of employees, encourage and, as far as possible, ensure that all persons employed in the preparation, distribution and handling of foodstuffs on their premises comply with the rules relating to employees.

17. Persons engaged in the preparation of foodstuffs must wear a suitable clean head covering.

18. A copy of this Code of Practice shall be exhibited on the premises for the information of all concerned in the handling or distribution of food.

The conditions contained in this Code are without prejudice to any statutory requirements that may from time to time be in force.

EMPLOYEES

1. Employees must see that a high standard of personal cleanliness is maintained in regard to :—

   (*a*) Hands and finger-nails should be scrubbed clean before commencing work, and after every visit to a sanitary convenience, and as often as necessary.

   (*b*) Overalls must be changed as frequently as necessary to maintain a clean appearance.

   (*c*) Smoking during the preparation, handling and distribution of foodstuffs is prohibited.

2. Premises, fixtures, fittings, etc., for which the individual employee is responsible must be kept clean at all times.

3. Employees must undertake to do everything possible to support the efforts of employers in preparing, handling and distributing food in a thoroughly clean and hygienic manner.

4. Employees must immediately notify their employer if suffering from or in contact with an infectious or contagious disease.

Cooked Food Premises—Code of Practice

Standards to be maintained for Membership of the Guildford Hygienic Food Traders' Guild

1. The walls, ceilings, floors, windows and doors of every room, store and shop wherein food is prepared, stored or distributed shall be kept in a proper state of repair so as to maintain a high standard of cleanliness.

2. The walls, ceilings, window-frames and doors shall be painted and redecorated as often as may be necessary, and at least once in every three months shall be so washed or cleansed as to maintain the premises in a clean condition ; and the windows shall be kept clean at all times.

3. There shall be adequate natural and/or artificial light to enable the various processes to be carried out in a hygienic manner.

4. There shall be provided adequate means of ventilation, preferably from the open air, and sufficient ventilation shall be maintained.

5. No refuse or filth, whether solid or liquid, shall be deposited or allowed to accumulate on or about the premises, and all floors, yards and passages shall be kept clean. A sufficient number of covered receptacles shall be provided and maintained for trade and other refuse.

6. All equipment, including cooking utensils, storage receptacles, trays and shop fittings, shall be thoroughly cleansed and maintained in a clean condition. Vehicles used in connection with food distribution shall be thoroughly cleansed at least once weekly.

7. There shall be provided in a readily accessible position, and, if possible, adjacent to sanitary accommodation, a sufficient number of fitted wash-basins or sinks provided with a constant supply of hot and cold water. There shall also be provided adequate supplies of clean towels, soap and nail-brushes for the use of persons employed.

8. Adequate sanitary accommodation, separate for the sexes, shall be provided and maintained in a clean condition.

9. No sanitary accommodation or dust-bin shall be within or communi-

cate directly with the rooms or be so placed that offensive odours therefrom can penetrate into the rooms.

10. No cistern for the supply of water to the rooms shall be in direct communication with or discharge directly into a sanitary convenience, and there shall not be within the room any outlet for the ventilation of a drain or any inlet into any soil water drain.

11. All foodstuffs to be protected from contamination by dust, dirt, flies, etc., and for this purpose protection to open displays of goods must be provided by suitable coverings.

12. In so far as present conditions allow, food must be wrapped in clean hygienic wrappers, and, wherever possible, a clean new inner wrapping should be used in addition to any newspaper which may be used.

13. Persons engaged in the preparation of foodstuffs must wear a suitable head covering.

14. Personal clothing of employees not worn whilst working must not be kept in a room where food is being prepared, stored or sold, except in a cupboard provided for the purpose.

15. Members of the Guild will ensure that all foodstuffs sold are clean, fresh and in all respects fit for human consumption.

16. The premises shall at all times be kept free from infestation by rats, mice, beetles, flies and any other vermin and/or insects, and in the event of any such infestation arising immediate action must be taken for treatment through the Local Authority or otherwise.

17. Employers shall take reasonable precautions to ascertain if any of their staff are suffering from or have been in contact with any infectious or contagious disease, and should any such case occur the employer shall immediately notify the Medical Officer of Health.

18. Employers shall, having provided all reasonable facilities for the personal cleanliness of employees, encourage and, as far as possible, ensure that all persons employed in the preparation, distribution and handling of foodstuffs on their premises comply with the rules relating to employees.

19. A copy of this Code of Practice shall be exhibited on the premises for the information of all concerned in the handling or distribution of food.

The conditions contained in this Code are without prejudice to any statutory requirements that may from time to time be in force.

EMPLOYEES

1. Employees must see that a high standard of personal cleanliness is maintained in regard to :—

   (*a*) Hands and finger-nails should be scrubbed clean before commencing work, and after every visit to a sanitary convenience, and as often as necessary.

   (*b*) Overalls must be changed as frequently as necessary to maintain a clean appearance.

   (*c*) Smoking during the preparation, handling and distribution of foodstuffs is prohibited.

2. Premises, fixtures, fittings, etc., including vehicles, for which the individual employee is responsible must be kept clean at all times.

3. Employees must undertake to do everything possible to support the efforts of employers in preparing, handling and distributing food in a thoroughly clean and hygienic manner.

4. Employees must immediately notify their employer if suffering from or in contact with an infectious or contagious disease.

Dairies—Code of Practice

Standards to be maintained for Membership of the Guildford Hygienic Food Traders' Guild

1. The walls, ceilings, floors, windows and doors of every dairy wherein milk is processed, stored or distributed shall be kept in a proper state of repair so as to maintain a high standard of cleanliness.
2. The walls, ceilings, window-frames and doors shall be painted and redecorated as often as may be necessary, and at least once in every month shall be so cleansed as to maintain the premises in a clean condition ; and the windows shall be kept clean at all times.
3. There shall be adequate natural and/or artificial light to enable the various processes to be carried out in a hygienic manner.
4. There shall be provided adequate means of ventilation, preferably from the open air, and sufficient ventilation shall be maintained.
5. No refuse or filth, whether solid or liquid, shall be deposited or allowed to accumulate on or about the premises, and all floors, yards and passages shall be kept clean. A sufficient number of covered receptacles shall be provided and maintained for trade and other refuse.
6. All plant, utensils, churns, etc., used in connection with the processing or handling of milk shall be thoroughly cleansed before use and subsequently sterilised by steam, and when not in use such utensils shall be stored in such a manner as to exclude all contamination by dirt, dust, etc.
7. All bottles used in connection with the distribution of milk shall be thoroughly cleansed and sterilised immediately before use, and all broken, chipped or otherwise unsuitable bottles shall be withdrawn from further use.
8. All other equipment, including shop fittings and vehicles, shall be thoroughly cleansed and maintained in a clean condition.
9. There shall be provided in a readily accessible position, and, if possible, adjacent to sanitary accommodation, a sufficient number of fitted wash-basins or sinks provided with a constant supply of hot and cold water. There shall also be provided adequate supplies of clean towels, soap and nail-brushes for the use of persons employed.
10. Adequate sanitary accommodation, separate for the sexes, shall be provided and maintained in a clean condition.
11. No sanitary accommodation or dustbin shall be within or communicate directly with the dairy or be so placed that offensive odours therefrom can penetrate into the dairy.
12. No cistern for the supply of water to the dairy shall be in direct communication with or discharge directly into a sanitary convenience, and there shall not be within the dairy any outlet for the ventilation of a drain or any inlet into any soil water drain.
13. The premises shall at all times be kept free from infestation by rats, mice, beetles, flies and any other vermin and/or insects, and in the event of any such infestation arising immediate action will be taken for treatment through the Local Authority or otherwise.
14. The milk shall at all times be properly covered and effectively protected from dust, dirt, flies or other sources of contamination.

15. Dairymen shall instruct employees engaged in the collection or distribution of milk that such milk (including crates of full bottles) must not be deposited on the highway or other place where contamination is likely to arise, or where the milk will be exposed to direct heat from the sun.

16. Personal clothing of employees not worn whilst working must not be kept in a room where milk is being processed, stored or sold, except in a cupboard provided for the purpose.

17. Members of the Guild will ensure that all milk sold is clean, fresh and in all respects fit for human consumption.

18. Vehicles used in connection with the distribution of milk, whether by wholesale or retail, shall bear the full name and address of the vendors.

19. During warm weather, vehicles used for transporting supplies of milk shall be so covered as to protect the milk from the sun to ensure a reasonably cool temperature being maintained.

20. Employers shall take reasonable precautions to ascertain if any of their staff are suffering from or have been in contact with any infectious or contagious disease, and should any such case occur the employer shall immediately notify the Medical Officer of Health.

21. Employers shall, having provided all reasonable facilities for the personal cleanliness of employees, encourage and, as far as possible, ensure that all persons employed in the processing, distribution and handling of milk on their premises comply with the rules relating to employees.

22. Persons engaged in the processing of milk must wear a suitable clean head covering.

23. A copy of this Code of Practice shall be exhibited on the premises for the information of all concerned in the processing, handling and distribution of milk.

The conditions contained in this Code are without prejudice to any statutory requirements that may from time to time be in force.

EMPLOYEES

1. Employees must see that a high standard of personal cleanliness is maintained in regard to :—

   (*a*) Hands and finger-nails should be scrubbed clean before commencing work, and after every visit to a sanitary convenience, and as often as necessary.

   (*b*) Overalls must be changed as frequently as necessary to maintain a clean appearance.

   (*c*) Smoking during the processing, handling and distribution of loose milk is prohibited.

2. Premises, fixtures, fittings, etc., including vehicles, for which the individual employee is responsible must be kept clean at all times.

3. Employees engaged in the collection or distribution of milk must not deposit such milk (including crates of full bottles) on the highway or in any other place where contamination is likely to arise, or where the milk will be exposed to direct heat from the sun.

4. Employees must undertake to do everything possible to support the efforts of employers in processing, handling and distributing milk in a thoroughly clean and hygienic manner.

5. Employees must immediately notify their employer if suffering from or in contact with an infectious or contagious disease.

FISHMONGERS AND FISH FRYERS—CODE OF PRACTICE

Standards to be maintained for Membership of the Guildford Hygienic Food Traders' Guild

1. The walls, ceilings, floors, windows and doors of every shop, store or room wherein food is prepared, stored or distributed shall be kept in a proper state of repair so as to maintain a high standard of cleanliness.

2. The walls, ceilings, window-frames and doors shall be painted and redecorated as often as may be necessary, and at least once in every month shall be so cleansed as to maintain the premises in a clean condition ; and the windows shall be kept clean at all times.

3. There shall be adequate natural and/or artificial light to enable the various processes to be carried out in a hygienic manner.

4. There shall be provided adequate means of ventilation, preferably from the open air, and sufficient ventilation shall be maintained.

5. No refuse or filth, whether solid or liquid, shall be deposited or allowed to accumulate on or about the premises, and all floors, yards and passages shall be kept clean. A sufficient number of covered receptacles shall be provided and maintained for trade waste and other refuse.

6. All equipment, including storage receptacles, trays, shop fittings and vehicles, shall be thoroughly cleansed and maintained in a clean condition, and all used fish-boxes shall be so cleansed immediately after emptying and returned in a clean condition.

7. There shall be provided in a readily accessible position, and, if possible, adjacent to sanitary accommodation, a sufficient number of fitted wash-basins or sinks provided with a constant supply of hot and cold water. There shall also be provided adequate supplies of clean towels, soap and nail-brushes for the use of persons employed.

8. Adequate sanitary accommodation, separate for the sexes, shall be provided and maintained in a clean condition.

9. No sanitary accommodation or dustbin shall be within or communicate directly with the rooms, or be so placed that offensive odours therefrom can penetrate into the rooms.

10. No cistern for the supply of water to the rooms shall be in direct communication with or discharge directly into a sanitary convenience, and there shall not be within the room any outlet for the ventilation of a drain or any inlet into any soil water drain.

11. All foodstuffs must be protected from contamination by dust, dirt, flies, etc., and for this purpose adequate facilities for the spraying of wet fish whilst on display shall be provided.

12. All fish-frying ranges shall be thoroughly cleansed at least once weekly, and all media removed from pans for clarifying at least once monthly so that a thorough cleansing of the pans can be carried out at the same time.

13. Adequate cold-storage accommodation (e.g. ice-box, refrigerator, etc.) shall be provided for the storage of fish which has not been sold at the end of the day.

14. Wherever possible, separate and suitable accommodation, with a constant water supply and a sufficient number of sinks for the purpose, shall be provided for the gutting, cleansing and preparation of fish for sale.

15. In so far as present conditions allow, food must be wrapped in clean hygienic wrappers, and, wherever possible, a clean new inner wrapping should be used in addition to any newspaper which may be used.

16. Members of the Guild will ensure that all foodstuffs sold are clean, fresh and in all respects fit for human consumption.

17. The premises shall at all times be kept free from infestation by rats, mice, beetles, flies and any other vermin and/or insects, and in the event of any such infestation arising immediate action will be taken for treatment through the Local Authority or otherwise.

18. Employers shall take reasonable precautions to ascertain if any of their staff are suffering from or have been in contact with any infectious or contagious disease, and should any such case occur the employer shall immediately notify the Medical Officer of Health.

19. Personal clothing of employees not worn whilst working must not be kept in a room where food is being prepared, stored or sold, except in a cupboard provided for the purpose.

20. Employers shall, having provided all reasonable facilities for the personal cleanliness of employees, encourage and, as far as possible, ensure that all persons employed in the preparation, distribution and handling of foodstuffs on their premises comply with the rules relating to employees.

21. A copy of this Code of Practice shall be exhibited on the premises for the information of all concerned in the handling or distribution of food.

The conditions contained in this Code are without prejudice to any statutory requirements that may from time to time be in force.

EMPLOYEES

1. Employees must see that a high standard of personal cleanliness is maintained in regard to :—

(*a*) Hands and finger-nails should be scrubbed clean before commencing work, and after every visit to a sanitary convenience, and as often as necessary.

(*b*) Overalls must be changed as frequently as necessary to maintain a clean appearance.

(*c*) Smoking during the preparation, handling and distribution of foodstuffs is prohibited.

2. Premises, fixtures, fittings, etc., including vehicles for which the individual employee is responsible, must be kept clean at all times.

3. All fish-frying ranges shall be thoroughly cleansed at least once weekly, and all media removed from pans for clarifying at least once monthly so that a thorough cleansing of the pans can be carried out at the same time.

4. Employees must undertake to do everything possible to support the efforts of employers in preparing, handling and distributing food in a thoroughly clean and hygienic manner.

5. Employees must immediately notify their employer if suffering from or in contact with an infectious or contagious disease.

Grocers and General Store—Code of Practice

Standards to be maintained for Membership of the Guildford Hygienic Food Traders' Guild

1. The walls, ceilings, floors, windows and doors of every shop, store and warehouse wherein food is prepared, stored or distributed shall be kept in a proper state of repair so as to maintain a high standard of cleanliness.

2. The walls, ceilings, window frames and doors shall be painted and

redecorated as often as may be necessary, and at least once in every three months shall be so washed or cleansed as to maintain the premises in a clean condition ; and the windows shall be kept clean at all times.

3. There shall be adequate natural and/or artificial light to enable the various processes to be carried out in a hygienic manner.

4. There shall be provided adequate means of ventilation, preferably from the open air, and sufficient ventilation shall be maintained.

5. No refuse or filth, whether solid or liquid, shall be deposited or allowed to accumulate on or about the premises, and all floors, yards and passages shall be kept clean. A sufficient number of covered receptacles shall be provided and maintained for trade and other refuse.

6. All equipment, including storage receptacles, trays and shop fittings, shall be thoroughly cleansed and maintained in a clean condition. Vehicles used in connection with food distribution shall be thoroughly cleansed at least once weekly.

7. There shall be provided in a readily accessible position, and, if possible, adjacent to sanitary accommodation, a sufficient number of fitted wash-basins or sinks provided with a constant supply of hot and cold water. There shall also be provided adequate supplies of clean towels, soap and nail-brushes for the use of persons employed.

8. Adequate sanitary accommodation, separate for the sexes, shall be provided and maintained in a clean condition.

9. No sanitary accommodation or dustbin shall be within or communicate directly with the rooms or be so placed that offensive odours therefrom can penetrate into the rooms.

10. No cistern for the supply of water to the rooms shall be in direct communication with or discharge directly into a sanitary convenience, and there shall not be within the room any outlet for the ventilation of a drain or any inlet into any soil water drain.

11. All unpacked foodstuffs to be protected from contamination by dust, dirt, flies, etc., whether inside or outside the premises, and for this purpose protection to open displays of goods must be provided by suitable coverings.

12. In so far as present conditions allow, food must be wrapped in clean hygienic wrappers, and, wherever possible, a clean new inner wrapping should be used in addition to any newspaper which may be used.

13. All personal clothing of employees not worn whilst working must not be kept in a room where food is being prepared, stored or sold, except in a cupboard provided for the purpose.

14. Members of the Guild will ensure that all foodstuffs are clean, fresh and in all respects fit for human consumption.

15. The premises shall at all times be kept free from infestation by rats, mice, beetles, flies and any other vermin and/or insects, and in the event of any such infestation arising immediate action will be taken for treatment through the Local Authority or otherwise.

16. Employers shall take reasonable precautions to ascertain if any of their staff are suffering from or have been in contact with any infectious or contagious disease, and should any such case occur the employer shall immediately notify the Medical Officer of Health.

17. Employers shall, having provided all reasonable facilities for the personal cleanliness of employees, encourage and, as far as possible, ensure that all persons employed in the preparation, distribution and handling of foostuffs on their premises comply with the rules relating to employees.

18. A copy of this Code of Practice shall be exhibited on the premises for the information of all concerned in the handling or distribution of food.

The conditions contained in this Code are without prejudice to any statutory requirements that may from time to time be in force.

EMPLOYEES

1. Employees must see that a high standard of personal cleanliness is maintained in regard to :—

(*a*) Hands and finger-nails should be scrubbed clean before commencing work, and after every visit to a sanitary convenience, and as often as necessary.

(*b*) Overalls must be changed as frequently as necessary to maintain a clean appearance.

(*c*) Smoking during the preparation, handling and distribution of foodstuffs is prohibited.

2. Premises, fixtures, fittings, etc., for which the individual employee is responsible must be kept clean at all times.

3. Employees must undertake to do everything possible to support the efforts of employers in preparing, handling and distributing food in a thoroughly clean and hygienic manner.

4. Employees must immediately notify their employer if suffering from or in contact with an infectious or contagious disease.

GREENGROCERS—CODE OF PRACTICE

Standards to be maintained for Membership of the Guildford Hygienic Food Traders' Guild

1. The walls, ceilings, floors, windows and doors of every shop and store wherein food is prepared, stored or distributed shall be kept in a proper state of repair so as to maintain a high standard of cleanliness.

2. The walls, ceilings, window-frames and doors shall be painted and redecorated as often as may be necessary, and at least once in every month shall be washed or cleansed so as to maintain the premises in a clean condition ; and the windows shall be kept clean at all times.

3. There shall be adequate natural and/or artificial light to enable the various processes to be carried out in a hygienic manner.

4. There shall be provided adequate means of ventilation, preferably from the open air, and sufficient ventilation shall be maintained.

5. No refuse or filth, whether solid or liquid, shall be deposited or allowed to accumulate on or about the premises, and all floors, yards and passages shall be kept clean. A sufficient number of covered receptacles shall be provided and maintained for trade and other refuse.

6. All equipment, including storage receptacles, trays, shop fittings and vehicles, shall be thoroughly cleansed and maintained in a clean condition.

7. There shall be provided in a readily accessible position, and, if possible, adjacent to sanitary accommodation, a sufficient number of fitted wash-basins or sinks provided with a constant supply of hot and cold water. There shall also be provided adequate supplies of clean towels, soap and nail-brushes for the use of persons employed.

8. Adequate sanitary accommodation, separate for the sexes, shall be provided and maintained in a clean condition.

9. No sanitary accommodation or dustbin shall be within or communicate

directly with the rooms, or be so placed that offensive odours therefrom can penetrate into the rooms.

10. No cistern for the supply of water to the rooms shall be in direct communication with or discharge directly into a sanitary convenience, and there shall not be within the room any outlet for the ventilation of a drain or any inlet into any soil water drain.

11. All open displays of goods for sale must, as far as practicable, be adequately protected from contamination.

12. Members of the Guild will ensure that all foodstuffs sold are fresh and in all respects fit for human consumption.

13. The premises shall at all times be kept free from infestation by rats, mice, beetles, flies and any other vermin and/or insects, and in the event of any such infestation arising immediate action will be taken for treatment through the Local Authority or otherwise.

14. Employers shall take reasonable precautions to ascertain if any of their staff are suffering from or have been in contact with any infectious or contagious disease, and should any such case occur the employer shall immediately notify the Medical Officer of Health.

15. Employers shall, having provided all reasonable facilities for the personal cleanliness of employees, encourage and, as far as possible, ensure that all persons employed in the preparation, distribution and handling of foodstuffs on their premises comply with the rules relating to employees.

16. A copy of this Code of Practice shall be exhibited on the premises for the information of all concerned in the handling or distribution of food.

The conditions contained in this Code are without prejudice to any statutory requirements that may from time to time be in force.

EMPLOYEES

1. Employees must see that a high standard of personal cleanliness is maintained in regard to :—

(*a*) Hands and finger-nails should be scrubbed clean before commencing work, and after every visit to a sanitary convenience, and as often as necessary.

(*b*) Overalls must be changed as frequently as necessary to maintain a clean appearance.

2. Premises, fixtures, fittings, etc., including vehicles, for which the individual employee is responsible must be kept clean at all times.

3. Employees must undertake to do everything possible to support the efforts of employers in preparing, handling and distributing food in a thoroughly clean and hygienic manner.

4. Employees must immediately notify their employer if suffering from or in contact with an infectious or contagious disease.

ICE-CREAM PREMISES—CODE OF PRACTICE

Standards to be maintained for Membership of the Guildford Hygienic Food Traders' Guild

MANUFACTURING PREMISES

1. Manufacturers of ice-cream shall provide and maintain a separate room or rooms set apart for the purpose.

2. The walls, ceilings, window-frames and doors of every room or store

wherein ice-cream is prepared, stored or distributed shall be kept in a proper state of repair so as to maintain a high standard of cleanliness.

3. The walls, ceiling, window-frames and doors shall be painted or redecorated as often as may be necessary, and at least once in every three months shall be so washed or cleansed as to maintain the premises in a clean condition.

4. There shall be adequate natural and artificial light to enable the various processes to be carried out in a hygienic manner.

5. There shall be provided adequate means of ventilation, preferably from the open air, and sufficient ventilation shall be maintained.

6. No refuse or filth, whether solid or liquid, shall be deposited or allowed to accumulate on or about the premises, and all floors, yards and passages shall be kept clean. A sufficient number of covered receptacles shall be provided and maintained for trade and other refuse.

7. Adequate facilities for the sterilisation of all equipment, utensils and plant used in the manufacture and sale of ice-cream shall be provided by means of a boiler or steam steriliser. All such equipment shall be thoroughly cleansed before sterilisation is carried out.

8. All other equipment, such as storage receptacles for ingredients, trays, fittings and vehicles, shall be thoroughly cleansed and maintained in a clean condition.

9. All equipment used in the manufacture and sale of ice-cream shall be kept separate for the purpose and used exclusively therefore, and during intervals between usage shall be stored in a separate place protected from dust, dirt, etc.

10. Dippers and measures used during the sale of ice-cream shall be kept in a vessel of clean water during intervals when sale is not in progress.

11. Suitable facilities shall be provided for the storage of ingredients used in the manufacture of ice-cream, so as to be properly protected from dust, dirt and vermin.

12. Pasteurisation plants used for the heat treatment of ice-cream under the Heat-treatment Regulations should have automatic recording thermometers fitted, and the charts from such recording thermometers shall be kept for at least one month for inspection by the authorised officers of the Local Authority.

13. There shall be provided in a readily accessible position a sufficient number of fitted wash-basins or sinks, provided with a constant supply of hot and cold water. There shall be provided also adequate supplies of clean towels, soap and nail-brushes for the use of persons employed.

14. Adequate sanitary accommodation, separate for the sexes, shall be provided and maintained in a clean condition.

15. No sanitary accommodation or dustbin shall be within or communicate directly with the rooms or be so placed that offensive odours therefrom can penetrate into the rooms.

16. No cistern for the supply of water to the rooms shall be in direct communication with or discharge directly into a sanitary convenience, and there shall not be within the room any outlet for the ventilation of a drain or any inlet into any soil water drain.

17. The premises shall at all times be kept free from infestation by rats, mice, beetles, flies and any other vermin and/or insects, and in the event of any such infestation arising immediate action will be taken for treatment through the Local Authority or otherwise.

18. Personal clothing of employees not worn whilst working must not be kept in a room where ice-cream is being prepared, stored or sold, except in a cupboard provided for the purpose.

19. Employers shall, having provided all reasonable facilities for the personal cleanliness of employees, encourage and, as far as possible, ensure that all persons employed in the preparation, distribution and handling of ice-cream on their premises comply with the rules relating to employees.

20. Members of the Guild will ensure that all ice-cream sold is clean and fresh and in all respects fit for human consumption.

21. Employers shall take reasonable precautions to ascertain if any of their staff are suffering from or have been in contact with any infectious or contagious disease, and should any such case occur the employer shall immediately notify the Medical Officer of Health.

22. A copy of this Code of Practice shall be exhibited on the premises for the information of all concerned in the handling or distribution of ice-cream.

DISTRIBUTING PREMISES (OTHER THAN MANUFACTURERS)

1. All receptacles containing ice-cream shall be kept covered and stored in such a manner as to eliminate contamination by dust, dirt or vermin.

2. On premises where ice-cream is sold loose a separate compartment within the premises shall be provided exclusively for the storage and sale of ice-cream.

3. All dippers, measures, etc., used during the sale of ice-cream shall be kept in a vessel of clean water during the intervals when sales are not in progress.

4. Adequate facilities for the sterilisation of all equipment, utensils and plant used in the sale of ice-cream shall be provided by means of a boiler, copper, or steam steriliser ; and all such equipment shall be thoroughly cleansed before sterilisation is carried out.

5. All equipment used in the sale of ice-cream shall be kept separate for the purpose and used exclusively therefor.

6. The walls, ceilings, floors, window-frames and doors of every room or store wherein ice-cream is stored or distributed shall be kept in a proper state of repair so as to maintain a high standard of cleanliness.

7. The walls, ceilings, window frames and doors shall be redecorated or painted as often as may be necessary, and at least once in every three months shall be so washed or cleansed as to maintain the premises in a clean condition ; and the windows shall be kept clean at all times.

8. There shall be adequate natural and/or artificial light to enable the various processes to be carried out in a hygienic manner.

9. There shall be provided adequate means of ventilation, preferably from the open air, and sufficient ventilation shall be maintained.

10. No refuse or filth, whether solid or liquid, shall be deposited or allowed to accumulate on or about the premises, and all floors, yards and passages shall be kept clean. A sufficient number of covered receptacles shall be provided and maintained for trade and other refuse.

11. There shall be provided in a readily accessible position a sufficient number of fitted wash-basins or sinks, provided with a constant supply of hot and cold water. There shall also be provided adequate supplies of clean towels, soap and nail-brushes for the use of persons employed.

12. Adequate sanitary accommodation, separate for the sexes, shall be provided and maintained in a clean condition.

13. No sanitary accommodation or dustbin shall be within or communicate directly with the rooms, or be so placed that offensive odours therefrom can penetrate into the rooms.

14. No cistern for the supply of water to the rooms shall be in direct communication with or discharge directly into a sanitary convenience, and there shall not be within the room any outlet for the ventilation of a drain or any inlet into any soil water drain.

15. The premises shall at all times be kept free from infestation by rats, mice, beetles, flies and any other vermin and/or insects, and in the event of any such infestation arising immediate action will be taken for treatment through the Local Authority or otherwise.

16. Personal clothing of employees not worn whilst working must not be kept in a room where ice-cream is being prepared, stored or sold, except in a cupboard provided for the purpose.

17. Employers shall, having provided all reasonable facilities for the personal cleanliness of employees, encourage and, as far as possible, ensure that all persons employed in the preparation, distribution and handling of ice-cream on their premises comply with the rules relating to employees.

18. Members of the Guild will ensure that all ice-cream sold is clean, fresh and in all respects fit for human consumption.

19. Employers shall take reasonable precautions to ascertain if any of their staff are suffering from or have been in contact with any infectious or contagious disease, and should any such case occur the employer shall immediately notify the Medical Officer of Health.

20. A copy of this Code of Practice shall be exhibited on the premises for the information of all concerned in the handling or distribution of food.

VEHICLES FROM WHICH ICE-CREAM IS SOLD

1. All vehicles from which ice-cream is sold shall have the name and address of the vendor prominently displayed.

2. All such vehicles shall be so constructed as to allow for thorough cleansing daily, and shall be maintained in a clean condition.

3. All such vehicles shall carry a receptacle containing a supply of clean water in which dippers, measures, etc., can be placed when ice-cream is not being sold.

4. Persons responsible for the sale of ice-cream from vehicles shall carry a supply of clean water, towels and soap for the washing of hands.

5. Receptacles containing ice-cream biscuits, cones, etc., shall be kept covered and protected from contamination during intervals when sales are not in progress.

6. Provisions shall be made for the storage of ice-cream on the vehicle which will ensure that it will be kept at a temperature not exceeding 28° F., in accordance with the Ice-Cream (Heat-treatment, etc.) Regulations, 1947.

7. All vehicles from which the ice-cream is sold shall, when not in use for the sale of ice-cream, be kept in clean premises, and all equipment removed to registered premises where facilities are provided for thorough cleansing and sterilisation and storage under suitable conditions.

The conditions contained in this Code are without prejudice to any statutory requirements that may from time to time be in force.

EMPLOYEES

1. Employees must see that a high standard of personal cleanliness is maintained, e.g. :—

   (*a*) Hands and finger-nails should be scrubbed clean before commencing work, and after every visit to a sanitary convenience, and as often as necessary.

   (*b*) Persons engaged in the preparation of ice-cream must wear a suitable clean head covering.

   (*c*) Overalls must be changed as frequently as necessary to maintain a clean appearance.

   (*d*) Smoking during the preparation, handling and distribution of ice-cream is prohibited.

2. Premises, fixtures, fittings, etc., including vehicles, for which the individual employee is responsible must be kept thoroughly clean at all times, and all equipment used in the manufacture or sale of ice-cream must be thoroughly cleansed and sterilised in accordance with the standards laid down for employers.

3. Employees must undertake to do everything possible to support the efforts of employers in preparing, handling and distributing ice-cream in a thoroughly clean and hygienic manner.

4. Employees must immediately notify their employer if suffering from or in contact with an infectious or contagious disease.

SWEET SHOPS, ETC.—CODE OF PRACTICE

Standards to be maintained for Membership of the Guildford Hygienic Food Traders' Guild

1. The walls, ceilings, floors, windows and doors of every shop, room and store wherein sweets, etc., are prepared, stored or distributed shall be kept in a proper state of repair so as to maintain a high standard of cleanliness.

2. The walls, ceilings, window-frames and doors shall be painted and redecorated as often as may be necessary, and at least once in every month shall be so washed or cleansed as to maintain the premises in a clean condition ; and the windows and floors shall be kept clean at all times.

3. There shall be adequate natural and/or artificial light to enable the various processes to be carried out in a hygienic manner.

4. There shall be provided adequate means of ventilation, preferably from the open air, and sufficient ventilation shall be maintained.

5. No refuse or filth, whether solid or liquid, shall be deposited or allowed to accumulate on or about the premises, and all floors, yards and passages shall be kept clean. A sufficient number of covered receptacles shall be provided and maintained for trade and other refuse.

6. All equipment, including storage receptacles, trays and shop fittings, shall be thoroughly cleansed and maintained in a clean condition.

7. There shall be provided in a readily accessible position, and, if possible, adjacent to sanitary accommodation, a sufficient number of fitted wash-basins or sinks provided with a constant supply of hot and cold water. There shall also be provided adequate supplies of clean towels, soap and nail-brushes for the use of persons employed.

8. Adequate sanitary accommodation, separate for the sexes, shall be provided and maintained in a clean condition.

9. No sanitary accommodation or dustbin shall be within or communicate directly with the rooms or be so placed that offensive odours therefrom can penetrate into the rooms.

10. No cistern for the supply of water to the rooms shall be in direct communication with or discharge directly into a sanitary convenience, and there shall not be within the room any outlet for the ventilation of a drain or any inlet into any soil water drain.

11. All foodstuffs to be protected from contamination by dust, dirt, flies, etc., and for this purpose protection to open displays of goods must be provided by suitable coverings.

12. In so far as present conditions allow, food must be wrapped in clean hygienic wrappers, and, wherever possible, a clean new inner wrapping should be used in addition to any newspaper which may be used.

13. Persons engaged in the preparation of foodstuffs must wear a suitable head covering.

14. Personal clothing of employees not worn whilst working must not be kept in a room where food is being prepared, stored or sold, except in a cupboard provided for the purpose.

15. The premises shall at all times be kept free from infestation by rats, mice, beetles, flies and any other vermin and/or insects, and in the event of any such infestation arising immediate action will be taken for treatment through the Local Authority or otherwise.

16. Employers shall take reasonable precautions to ascertain if any of their staff are suffering from or have been in contact with any infectious or contagious disease, and should any such case occur the employer shall immediately notify the Medical Officer of Health.

17. All personal clothing of employees not worn whilst working must not be kept in a room where food is being prepared, stored or sold except in a cupboard provided for the purpose.

18. Employers shall, having provided all reasonable facilities for the personal cleanliness of employees, encourage and, as far as possible, ensure that all persons employed in the preparation, distribution and handling of sweets, etc., on their premises comply with the rules relating to employees.

19. A copy of this Code of Practice shall be exhibited on the premises for the information of all concerned in the handling or distribution of sweets, etc.

The conditions contained in this Code are without prejudice to any statutory requirements that may from time to time be in force.

EMPLOYEES

1. Employees must see that a high standard of personal cleanliness is maintained in regard to :—

   (*a*) Hands and finger-nails should be scrubbed clean before commencing work, and after every visit to a sanitary convenience, and as often as necessary.

   (*b*) Overalls must be changed as frequently as necessary to maintain a clean appearance.

   (*c*) Smoking during the preparation, handling and distribution of sweets, etc., is prohibited.

2. Premises, fixtures, fittings, etc., for which the individual employee is responsible must be kept clean at all times.

3. Employees must undertake to do everything possible to support the

efforts of employers in preparing, handling and distributing sweets, etc., in a thoroughly clean and hygienic manner.

4. Employees must immediately notify their employer if suffering from or in contact with an infectious or contagious disease.

Additional Code of Practice

CONDITIONS OF MANUFACTURE AND SALE OF FOOD NOT INTENDED FOR HUMAN CONSUMPTION

For inclusion in Code of Practice relating to :—

1. Cafés and Restaurants.
2. Cooked Food Premises.
3. Grocers and General Stores.
4. Butchers.
5. Bakehouses and Confectioners.
6. Fishmongers and Fish Fryers.

Premises in which food intended for human consumption is manufactured, prepared, stored or sold shall not be used for the manufacture or preparation of animal feeding stuffs or other foods not intended for human consumption.

All foods not intended for human consumption which are sold on premises on which food is also sold for human consumption shall bear a label clearly marked with the words "Not for human consumption," and shall be kept or stored separately in receptacles kept specially for the purpose. Utensils used in connection with the sale of such foods shall not be used in connection with the sale of food for human consumption.

Nothing in this article shall apply to foods packed in sealed containers, whether for human consumption or otherwise.

Additional Code of Practice

SALE OF ICE-CREAM AT FAIRS, FETES AND SIMILAR SOCIAL FUNCTIONS

(For inclusion in Codes of Practice relative to Ice-cream Manufacturers and Distributing Premises (other than Manufacturers)

All ice-cream sold to proprietors or organisers of fairs, fetes and similar social functions open to the public shall, as far as possible, be supplied as a pre-packed article in individual portions, when such ice-cream will not be under the control of the manufacturer or wholesaler concerned during sale. The ice-cream shall also be delivered to the place of delivery in freezers or containers which will enable it to be stored at a temperature not exceeding 28° F. until required for use.

APPENDIX 2

MODEL BYE-LAWS *

Handling, Wrapping and Delivery of Food and Sale of Food in the Open Air

In October, 1949, the Minister of Food issued model bye-laws aimed at improving the control of food sales. These were drafted after consultation with interested parties, and take the place of those formerly issued by the Minister of Health, which have to some extent become obsolete. These bye-laws, which are adoptive, can be put into force by any local authority, after ministerial approval, under section 15 of the Food and Drugs Act, 1938. Since being issued, they have been adopted by a large number of local authorities. These bye-laws should go a long way towards securing improvement in the handling and sale of foodstuffs. Owing to their importance, they are quoted in full in succeeding pages. Suggestions have been put forward for their improvement. These, together with certain notes regarding their contents, will be found at the end of each paragraph.

Before setting out the various bye-laws, it should be noted that bye-laws 2, 3, 4 (except 4 (*e*)) and 5 apply wherever food is handled, wrapped or delivered, whether in a room or in the open air. Bye-laws 4 (*e*) and 6 apply to food handling in rooms only, while bye-laws 7, 8, 9 and 10 apply wherever food is sold or exposed for sale in the open air. Compliance with bye-laws 6 and 9 is laid upon persons carrying on a trade or business, the duty of complying with the remainder of the byelaws not being restricted in any way. The deposit and removal of refuse is covered by a number of bye-laws. Bye-laws 5 (*c*) and 8 (*a*) require that refuse shall not be deposited near food, bye-law 4 (*e*) that refuse shall be placed in suitable receptacles in rooms, and bye-law 6 (*a*) that such receptacles shall be periodically emptied. No requirement for the provision of refuse receptacles in the open air is made, as the removal of refuse from street markets, etc. is already a matter for the local authority.

There is little doubt that more extensive provisions would probably have been included but for the present shortages of equipment and materials. A review of the working of the bye-laws at some subsequent date may bring about extensive changes.

BYE-LAWS made under section 15 of the Food and Drugs Act, 1938, by the [Mayor, Alderman and Burgesses of the Borough of   acting by the Council] [Urban/Rural District Council of   ] [Common Council of the City of London] [London County Council] for securing the observance of sanitary and cleanly conditions and practices in connection with the handling, wrapping and delivery of food sold or intended for sale for human consumption, and in connection with the sale or exposure for sale in the open air of food intended for human consumption.

PART I

Interpretation

1. In these bye-laws—

"cleanliness" means cleanliness having regard to the nature and packing of the food and the operation being performed and "clean" shall be construed accordingly ;

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" container " includes any basket, pail, box, tray or other receptacle ;

" contamination " includes contamination by odour, and shall be construed as having regard to the nature of the food and any refining process to which the food is normally subjected before sale to a consumer ;

" food " means any article sold or intended for sale for use as food or drink for human consumption other than cows' milk, drugs or water, and includes—

(*a*) any substance which is intended for use in the composition or preparation of food ;
(*b*) any flavouring matter or condiment ; and
(*c*) any colouring matter intended for use in food ;

Cows' milk has been excluded from this definition because there are Regulations in force which fully cover all aspects of production, handling and sale.

" handling " and " wrapping " include the handling and wrapping, respectively, of food in the course of any operation, including manufacture, processing, preparation, storage, delivery, sale and exposure for sale, in which such food is handled or wrapped ;

" milk " includes cream, skimmed milk and separated milk but does not include dried milk or condensed milk ;

" reasonably necessary " shall be construed as having regard to the nature and packing of the food, the operation being performed, and any refining process to which the food is normally subjected before sale to a consumer ;

" returnable fish container " " returnable ice-cream can " and " returnable biscuit tin " mean, respectively, a container in which fish is delivered, a can in which ice-cream is delivered, and a tin in which biscuits are delivered by a seller to a buyer upon the terms that the container, the can or the tin, as the case may be, is to be or may be returned to such seller ;

" room " includes a shop or cellar or any other part of building and a shed, store or outbuilding or any part thereof ;

" sale and exposure for sale " includes sale as a meal or part of a meal ;

" sanitary convenience " includes a watercloset, urinal, earth-closet, privy and any similar convenience ;

" stall " includes any stand, mobile canteen, car, barrow, or any other vehicle whether movable or immovable.

PART II

HANDLING, WRAPPING AND DELIVERY

2. Every person who handles, wraps or delivers any food shall observe cleanliness both in regard to himself and his clothing.

The standard of cleanliness to be observed naturally depends on the nature and packing of the food involved and the operations performed. It would also appear reasonable to require that overalls or aprons of clean washable material should be worn by all persons handling, wrapping or delivering foodstuffs susceptible to contamination.

3. No person knowingly suffering from or knowingly being a carrier of any disease shall handle, wrap or deliver any food so as to give rise to any risk of the spread of the disease. A person shall be deemed to have known that he was suffering from or was a carrier of a disease if he could with ordinary care have ascertained the fact.

It should be noted that the words " contagious " or " infectious " have not been used in connection with disease, thus widening the scope of this bye-law.

4. Every person who handles, wraps, or delivers, or causes to be handled wrapped or delivered any food shall—

(*a*) take all such steps as may be reasonably necessary to protect the food from dust, dirt, mud, filth, dirty water, animals, rodents, flies, insects, and other sources of contamination including contamination by other persons, and in particular shall cause the food to be so placed as to prevent risk of contamination from such sources ;

Contamination includes contamination by odour, and account should be taken of the nature of the food and any refining process to which the food is normally subjected before sale to the consumer. It would appear reasonable to prohibit smoking in many food-handling premises. Food should not be placed in any situation where it can be contaminated by cats or dogs. In particular, it should never be placed lower than 18 inches from ground level. In view of the possibility of cats and dogs carrying Salmonella infection, such animals should not be allowed in any food shops or food rooms. Unwrapped sweets should be served by means of scoops and not by hand, while foodstuffs should, wherever possible, be covered in glass display cabinets, by cellophane covers or by clean muslin wrappers, etc., when exposed for sale.

(*b*) where it is reasonably necessary during delivery to protect the food from such sources of contamination as are set out in the preceding paragraph, cover and keep covered or cause to be covered and kept covered such food during transit with suitable clean material :

Provided that this paragraph of this bye-law shall not apply to meat (including bacon and ham) in course of transit to any premises from, or from any premises to, a vehicle standing immediately outside the door of the premises ;

Meat in transit between van and premises is exempted from the requirements of this bye-law, due, it is stated, to the present scarcity of protective materials. When supplies improve, this proviso will no doubt be deleted.

(*c*) clean or cause to be cleaned as often as may be reasonably necessary to prevent risk of contamination of the food all counters, slabs, fittings, apparatus, stoves and ranges, utensils, crockery and cutlery, and surfaces with which the food is in or is liable to come into contact ;

A single sink for washing crockery and cutlery in restaurant kitchens does not appear to be sufficient to satisfy the requirements of this section.

(*d*) keep or cause to be kept clean the interior of every vehicle and every container from which the food is delivered ;

Bakers' delivery vans should, in particular, be thoroughly cleansed at least once each week.

(*e*) where the food is handled, wrapped or delivered in a room, in so far as it is necessary to allow any refuse or filth whether solid or liquid to be deposited or to accumulate in the room for the proper carrying on of the trade or business for which the room is used, place or cause to be placed all such refuse or filth in receptacles kept for the purpose.

5. No person who handles, wraps or delivers, or causes to be handled, wrapped or delivered any food shall—

(*a*) use or cause to be used for wrapping or containing the food any paper or other wrapping material or container which is not clean or which is liable to contaminate the food ;

(*b*) return or cause to be returned any returnable fish container, returnable ice-cream can or returnable biscuit tin except in a clean condition ;

(*c*) deposit or cause to be deposited any refuse or filth whether solid or liquid except at a sufficient distance from any food as to prevent risk of contamination of such food ;

(*d*) handle or wrap or cause to be handled or wrapped any food unless there is suitable and sufficient lighting, either natural or artificial, to enable him to ensure that these bye-laws are complied with ;

(*e*) carry or cause to be carried in the course of delivery any food in a vehicle or container along with any article liable to contaminate the food, or with any live animal or poultry, without taking all reasonably necessary precautions to prevent contamination.

Shortage of wrapping paper has prevented the inclusion of a positive requirement as to the wrapping of food on retail sale. It is suggested that consideration of a requirement as to the wrapping of particular foods will be given when supplies of suitable materials improve. On the other hand, traders should be encouraged to use new white wrapping paper for the preliminary packaging of food.

6. Every person who carries on a trade or business in which food is handled, wrapped or delivered in a room shall—

(*a*) in so far as it is necessary to allow refuse or filth whether solid or liquid to be deposited or to accumulate in the room for the proper carrying on of the trade or business for which the room is used—

(i) provide and maintain suitable receptacles for such refuse or filth, such receptacles (a) to be constructed of impervious materials or to be replaced as often as may be necessary to prevent the accumulation of obnoxious matter, (b) to be kept reasonably clean, and (c) where reasonably necessary to have close fitting lids ;

(ii) cause all such refuse or filth to be permanently removed from the room [at least once a day and] as often as may be necessary to prevent the contamination of food in the room ;

The brackets enclosing the words " at least once a day and " might well have been omitted.

(*b*) provide and maintain in every part of the room suitable and sufficient means of lighting, either natural or artificial, to enable these bye-laws to be complied with, except where such lighting is provided and maintained by some other person ;

(*c*) cause all surfaces with which the food is in or is liable to come into contact, including such surfaces of counters, slabs, fittings, apparatus, stoves and ranges, utensils, crockery and cutlery, and the interior of vehicles and containers from which the food is delivered, to be of such materials and to be kept in such good order, repair and condition as to prevent as far as is reasonably necessary the absorption of any food, material or refuse which may be spilled, splashed or deposited thereon, or brought into contact therewith, and to make it possible for such surfaces to be thoroughly cleaned ;

(*d*) cause to be affixed and maintained in a prominent and suitable position near every sanitary convenience provided by him for the use of employees in that business a clearly legible notice requesting such employees to wash their hands after using the convenience.

A requirement that employees should wash their hands would no doubt be difficult to enforce. This operation should be stressed by means of educational measures.

PART III

SALE AND EXPOSURE FOR SALE IN THE OPEN AIR

7. Every person who sells or exposes or causes to be exposed for sale in the open air any food shall—

(*a*) take all such steps as may be reasonably necessary to protect the food from dust, dirt, mud, filth, dirty water, animals, rodents, flies, insects, and other sources of contamination including contamination by other persons, and in particular shall cause the food to be so placed as to prevent risk of contamination from such sources ;

Food prepared for sale for immediate consumption should be protected by suitable coverings from contamination.

(*b*) clean or cause to be cleaned as often as may be reasonably necessary to prevent risk of contamination of the food all counters, slabs, fittings, apparatus, stoves and ranges, utensils, crockery and cutlery, and surfaces with which such food is in or is liable to come into contact.

To secure compliance with this requirement, a supply of clean hot and cold water, together with the necessary cleansing materials and equipment, should be readily available.

8. No person who sells or exposes or causes to be exposed for sale in the open air any food shall—

(*a*) deposit or cause to be deposited any refuse or filth whether solid or liquid except at a sufficient distance from any food as to prevent risk of contamination of such food ;

(*b*) expose or cause to be exposed such food for sale unless there is suitable and sufficient lighting, either natural or artificial, to enable him to ensure that these bye-laws are complied with.

9. Every person who carries on any trade or business in which food is exposed for sale from a stall or container in the open air shall—

(*a*) cause every part of the stall and its fittings or the container to be kept in such good order and condition as to prevent as far as is reasonably necessary the absorption of any food, material, or refuse which may be spilled, splashed, deposited thereon or brought into contact therewith, and as to make it possible for such stall and its fittings or such container to be thoroughly cleaned ;

(*b*) have his name and address legibly and conspicuously displayed on the stall or container and if he fails to comply with the requirements of this paragraph of this bye-law, shall be liable to a fine not exceeding forty shillings.

10. No person shall use any stall or container in the open air for the exposure for sale of food unless the stall or container is kept clean and in a proper state of repair.

PART IV

PENALTIES

11. Every person who shall offend against any of the foregoing byelaws shall, unless a special penalty is provided by any byelaw, be liable on summary conviction to a fine not exceeding five pounds and in the case of a continuing offence to a further fine not exceeding forty shillings for each day during which the offence continues after conviction therefor.

REPEAL OF BYELAWS*

12. The byelaws relating to the observance of sanitary and cleanly conditions and practices in connection with the handling, wrapping and delivery of food sold or intended for sale for human consumption, and in connection with the sale or exposure for sale in the open air of food intended for human consumption

which were made by the

on the day of

and were confirmed by

on the day of

are hereby repealed.

This proviso is necessary to prevent existing byelaws overlapping the suggested clauses.

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* If there are no byelaws in force, this clause should be struck out.

APPENDIX 3

HYGIENE IN CATERING ESTABLISHMENTS

Report of the Catering Trade Working Party

In their Report, which gives an excellent outline of the problem and indicates the broad lines for remedial action, the Working Party acknowledge the difficulties involved in bringing about rapid improvements in the hygienic condition of catering establishments, and the methods employed therein. The point is made that, in premises where methods could be improved, little is done, and that managements of many premises fail to recognise the need for training their staffs in methods of food hygiene.

Many unhygienic conditions found in catering establishments are listed, and have already been dealt with in Chapter XXVII. The Working Party point out that converted premises often allow too little space, and are inconvenient in arrangement. Underground kitchens create special difficulties. In some cases business expansion has made no allowance for the suitability of kitchen accommodation. Attention is drawn to the fact that hygiene will suffer if floors are defective, walls dirty, and ventilation and lighting inadequate. Lack of sanitary facilities, absence of washing accommodation, and lack of hot water for personal cleansing and for the treatment of utensils predispose to the risk of infection. The Report condemns the lack of supervision and control of possible infectious conditions, neglect of personal cleanliness by the employees, unnecessary handling of food, slow cooling of heated foods, failure to store prepared foods at low temperatures, exposure of food to vermin, and lack of suitable protection for displayed foods. It is also pointed out that cleanliness must be accompanied by safety. The technique of handling and preparation must be satisfactory, while inefficient methods should not be countenanced.

Certain important recommendations are made which, if carried out, should bring about substantial improvement in existing conditions. Distinction is made between what is essential and what is desirable, wherever this is possible, and it is pointed out that, owing to variations in catering establishments, the requirements must also vary. Two recommended codes of practice are set out. The Standard Code * as set out below contains only those requirements which can be considered essential and which should, with certain exceptions, apply to all *catering establishments* forthwith. The main provisions of the Standard Code are as follows :

1. Introduction

Food infections and food poisoning can be spread through food infected in catering establishments, and many outbreaks occur in this way. Such risks can be markedly reduced if suitable precautions are taken. It is the duty of both the management and staff to co-operate in all necessary and practicable steps to reduce food infection. The following procedures are designed to reduce the dangers of these infections.

2. Measures to Limit the Infection of Food from Food Handlers

(*a*) No person who is suffering from a discharging wound, sores on hands or arms, discharging ears or who is suffering from attacks of diarrhœa or vomiting should take part in the handling, preparation or serving of food in any catering establishment.

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(*b*) Members of the staff should report to the proprietor or manager if they are suffering from any of the conditions specified in (*a*) above or from any other illness.

(*c*) The proprietor (or manager) of a catering establishment should take reasonable steps to become aware of the existence amongst his staff of any of the conditions specified in (*a*) above or of any other illness.

(*d*) The proprietor (or manager) of a catering establishment, as soon as he becomes aware that any member of his staff is suffering from any of the above-specified conditions, should not permit such person to handle food until he (or she) is no longer suffering from the condition in question, or permission has been given by the Medical Officer of Health.

(*e*) In the case of other illnesses, if there is any doubt whether the employee should continue to work, the employee should be referred to his (or her) doctor pending resumption of work.

(*f*) Every applicant for employment should be informed of the possible risks from previous attacks of typhoid or paratyphoid fever, and should be asked if he (or she) has previously suffered from one of these diseases. If he (or she) has so suffered, particulars should be reported to the Medical Officer of Health and the applicant not engaged until approval has been given by the Medical Officer of Health.

3. MINIMUM HYGIENIC REQUIREMENTS

(*a*) Working premises must be kept clean. The cleanliness of a catering establishment calls for continuous and careful supervision with special regard to the nature of the business and of the premises. Among other things the floors must be swept daily, using damping agents ; the walls and other surfaces should be kept free from dust ; cupboards, drawers and other fixtures should be kept scrupulously clean and free from anything not used in food preparation. The floors of the food preparation rooms should be washed as frequently as necessary and at least daily.

(*b*) The premises must be adequately lit.

(*c*) Abundant supplies of water, both cold and hot, must be available.

(*d*) Nothing should be stored in rooms used for food preparation not directly concerned with the food work of the establishment.

(*e*) Accessible sanitary conveniences and wash-basins (sinks not being satisfactory substitutes for wash-basins) must be provided for the use of the staff, the wash-basins to be well lit and provided with an adequate supply of both hot and cold water. An adequate supply of towels and soap must also be provided. The wash-basins must be within the convenience or in the immediate vicinity. A notice pointing out the importance of washing hands after use of the sanitary convenience must be displayed in a prominent place in every convenience.

It is stated that the number of both wash-basins and sanitary conveniences required will vary with the number and sex of the staff. The provision of nail-brushes is also recommended, while it is pointed out that towels in communal use may carry infection and are therefore undesirable.

4. CLEANSING AND STERILISATION OF UTENSILS

(*a*) *Cleansing.* Adequate equipment for cleansing utensils must be provided. Where a dish-washing machine is installed, it must be efficient and efficiently operated, and in particular must provide for the thorough cleansing of utensils and for a subsequent rinse in clean water at such a temperature as will obviate the necessity for cloth drying. If no dish-washing machine is used, there must be at least two sinks with hot and cold water laid on to each sink. The first sink must be reserved for utensil cleansing, and the second sink for utensil rinsing. The water in the second sink must be kept clean and hot enough to obviate the necessity for cloth drying. Special consideration must be given to cleansing of all equipment used in the cooking and conveying of meals in bulk.

(*b*) *Sterilisation.* It is desirable that the arrangements for cleansing should provide also for sterilisation, but this may not be practicable in all cases. Sterilisation can be secured either by maintaining the temperature of the final rinse water at 170° F. or by steaming the utensils in a steam chest or large container, which can often be achieved, on the small scale, in an inexpensive way.

Some members of the Working Party considered that sterilisation of utensils should be made a specific requirement instead of being suggested as desirable. The Report also draws attention to the fact that the word "sterilisation" as used in the Code does not mean the complete freedom of a utensil from all living bacteria and spores, but rather freedom from all harmful bacteria in active form.

5. Care of Food on the Premises

(*a*) Suitable receptacles must be provided for all food.

(*b*) A refrigerator, cold room or ice-box, of size adequate for the establishment, must be provided.

(*c*) Perishable food must be kept in a larder or in the refrigerator, cold room or ice-box, whichever is suitable, until required for use.

(*d*) So far as is practicable all food preparation and cooking must be arranged to allow for a minimum interval before the food is consumed. When this is not practicable, any prepared or partially-prepared food must be stored in the refrigerator, cold room or ice-box immediately after preparation, or after rapid preliminary cooling of hot food, and not removed until required to complete preparation. So far as is practicable, all left-over food should not be used again, but if it is to be used it must be stored promptly in the refrigerator, cold room or ice-box.

(*e*) All foods used for display, apart from those exposed for immediate sale, must be protected by suitable wrappings or covers.

6. Rodent and Insect Infection

Occupiers of catering establishments must take all practicable steps to prevent or get rid of infestation and to prevent contamination of food from rats, mice, flies and other vermin. Covered receptacles of impervious material for refuse, food scraps and the like must be provided.

7. Hygienic Practices in Catering Establishments

Adherence to this Code alone is not enough. It is of prime importance that all members of the staff (management and workers) should be imbued with and continually practise the principles of sound personal hygiene and should take full advantage of any suitable courses of instruction which are available.

It is finally suggested that, in all matters dealt with in this Code, the local authority should be freely consulted.

A special code has been devised relating to the condition and equipment of *mobile vans and coffee stalls*,* the suggestions being as follows :

(1) The name and address of the person in whose name the establishment is registered shall be displayed conspicuously on the van or stall.

(2) The van or stall shall be adequately lit.

(3) The van or stall and its equipment shall be kept clean and in a proper state of repair. Cupboards, drawers and other fixtures shall be kept scrupulously clean and free from anything not necessary for the conduct of the business.

(4) The internal walls and surfaces shall be kept clean and free from vermin.

(5) All food shall be covered as far as practicable or shall be efficiently screened.

(6) A supply of wholesome water, both hot and cold, adequate for needs shall be available.

(7) There shall be available a supply of clean towels and soap for the use of the person or persons operating the stall or van.

(8) There shall be available adequate washing-up arrangements.

It is stated that in *public-houses and registered clubs* serving meals prepared on the premises, a single sink will suffice for glass cleansing, provided the occupier can satisfy the local authority that a properly-controlled and efficient bactericidal detergent is used, that the water is frequently changed, and that an adequate supply of clean cloths is available if cloths are used. This method of treating glassware is, however, only suggested as being satisfactory during a transitional period. It is recommended that two sinks should be available for glass washing, whilst it is also pointed out that the ideal system would be for glassware to be cleansed away from the bars where service is carried out.

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The Target Code of Practice * sets out the desirable standard to which it is hoped all *catering establishments* will ultimately achieve, and which should eventually apply to most of these premises. It includes those measures designed to ensure that all food served in catering establishments is prepared and served under the best possible conditions. The suggestions put forward in this Code are as follows :

A. The Working Premises

(1) The whole of the premises and fixtures should be so constructed and fitted that all parts of both premises and fixtures are capable of being readily cleansed.

(2) *Premises.* The premises should be large enough for an orderly sequence of work without undue crossing of traffic lines.

(3) *Cooking Equipment.* The cooking equipment should be so sited that wall areas adjacent thereto, and the equipment itself, are readily accessible for cleansing.

(4) *Floors.* The floors should be free from cracks, without open joints, impervious, non-slip and capable of being easily washed down. They should slope evenly towards the drainage outlet.

(5) *Walls.* The walls should be substantial, durable, smooth, impervious, washable and of a light colour.

(6) *Ceilings.* The ceilings should be dustproof and free from cracks.

(7) *Repair.* All premises should be maintained in sound repair and every precaution taken against infestation from vermin.

(8) *Drainage.* Gullies outside and in close proximity should be trapped. All yards should have impervious and even surfaces and should be properly drained.

(9) *Water Supply.* An adequate supply of wholesome water piped to taps over sinks, lavatory basins and other appropriate fixed receptacles should be provided.

(10) *Hot Water.* Apparatus to provide hot water up to at least 170° F. for all requisite purposes should be installed.

(11) *Lighting.* All parts of the premises used for food preparation should be adequately lit, preferably both by natural light and by artificial light.

(12) *Ventilation.* Adequate ventilation should be provided. Where a system of artificial ventilation is not installed an adequate flow of fresh air should be maintained.

(13) *Cloak-rooms.* Clean and adequate cloak-room accommodation should be provided for the staff distinct from, but preferably adjacent to, the food preparation rooms.

(14) *Sanitary Conveniences.* There should be a sufficient number of sanitary conveniences to meet the needs of the staff. Each convenience should have an adequate supply of toilet paper and should be well lit, ventilated and kept clean.

(15) *Washing Facilities.* There should be a sufficient number of wash-basins in immediate proximity to the sanitary conveniences, and elsewhere as may be necessary, to meet the needs of the staff. In addition a wash-basin should be fixed in the kitchen itself, or immediately adjacent thereto. (Kitchen sinks should not be used for hand washing.) All wash-basins should be well lit, with hot and cold water laid on, and should be kept clean. Soap, nail-brushes and towels (for non-common use) should be provided. (An efficient air drier is a satisfactory substitute for towels.)

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B. Equipment

(1) Adequate and suitable covered receptacles of impervious material for refuse, food scraps and the like, with a suitable and sufficient storage place for them, should be provided outside all food-preparation rooms.

(2) There should be proper receptacles constructed of impervious material for all foods broken down from the bulk. All except those for vegetables should have covers.

(3) There should be a cool larder of adequate size for the storage of foods, particularly those of a perishable nature.

(4) The surfaces of tables and benches should be impervious to liquids and without open cracks.

(5) There should be separate and adequate storage for all utensils and, in particular, covered racks for crockery, trays for cutlery and suitable shelving for saucepans and small cooking vessels.

(6) There should be a separate sink or sinks for vegetable preparation.

(7) Ventilated hoods or adequate alternative means for the removal of steam, fumes, intense heat from grillers, etc., should be provided wherever required.

(8) Adequate equipment for cleansing and sterilising utensils should be provided. Where a dish-washing machine is installed it should be worked efficiently and provide for the thorough cleansing of utensils and for their sterilisation. For hand-washing utensils the minimal provision should be :—

(*a*) A sink or sinks (according to the size of the establishment) for the washing of utensils, with hot and cold water laid on.

(*b*) A separate sink or sinks for sterilising, each furnished with its own supply of water which can be kept at a temperature of not less than 170° F., by steam injection or otherwise, with automatic devices for recording temperature ; sterilisation in a steam chest, if adequately carried out, may be accepted as an alternative. In a small establishment a two-compartment sink for washing and sterilising respectively may be used instead of two separate sinks, provided that the necessary device is available for recording the temperature ; or sterilisation can be effected by simple steaming in a suitable vessel.

(*c*) Metal racks with handles to hold utensils for immersion in the sterilising sink.

(9) There should be adequate shelves, hooks or racks to receive utensils for air-drying.

(10) There should be reserves of glass, crockery and cutlery to ensure :—

(*a*) The prompt replacement of chipped, cracked or bent equipment.

(*b*) That during rush hours there is no need to use inadequately sterilised equipment.

(11) A sufficient supply of overalls of light colour, caps, " rubbers " and other personal equipment should be provided.

(12) Where large containers are used for conveying meals (as in central kitchens for schools) a steam jet (or jets) should be provided, with steam available under adequate pressure. The lids as well as the containers need to be sterilised. An adequate time of steaming is essential, and a clock with a large minute hand should be provided adjacent to the steam jet. Adequate sterilisation in steam chests or in tanks containing boiling water may be accepted as a substitute in special cases.

(13) There should be a reliable refrigerator or cold room of size adequate for the establishment provided with an easily visible means of recording the inside temperature. (A cold room is one which is capable of maintaining food at a temperature not above 40° F.)

(14) Wrapping or covers or protective glass screens for food on display should be provided.

(15) First-aid equipment should be available on the premises.

C. Management Requirements

(1) The management should assign to a designated individual responsibility for checking the condition of all food delivered to the establishment and for taking action if it is considered unsatisfactory.

(2) Perishable articles (milk, meat, etc.) should be kept in the larder, adequately covered, or in the refrigerator or cold room until required for use.

(3) Manual handling of food should be avoided so far as practicable.

(4) Smoking while preparing or serving food should be prohibited.

(5) Animals should be excluded from rooms where food is being prepared. At no time should animals have access to food in the establishment.

(6) Nothing should be stored on the premises which is not directly concerned with the work of the establishment.

(7) All cooking vessels and other equipment should be maintained in a state of thorough cleanliness and repair, and all smaller utensils (saucepans, etc.) kept in their proper places when not in use. Particular care should be taken to maintain the linings of copper cooking utensils in such condition as to prevent direct contact between the foodstuffs and the copper.

(8) Premises should be maintained at a high standard of cleanliness. This involves washing floors at least once a day, supplemented by sweeping, using damping agents, as often as may be necessary and cleaning all walls and other surfaces at least once a week. All cupboards, drawers and other fixtures should be scrupulously clean and free from all articles other than those for which they are intended.

(9) A high standard of personal cleanliness on the part of the staff should be maintained. Overalls and other personal equipment should be washed and changed sufficiently frequently. Waiters should preferably wear washable jackets.

(10) A notice pointing out the importance of washing the hands after use of the sanitary convenience should be kept affixed in a prominent place in every convenience.

(11) So far as is practicable all food preparation should be done the same day as the food is consumed. When this is not practicable all partially-prepared food should be stored *immediately* after preparation in the refrigerator or cold room and not removed until required to complete final preparations. The only exception is that of a hot food of large bulk (such as a joint), which should be allowed to cool down in a clean place before being placed in the refrigerator or cold room. Rapid cooling of foods in bulk is so important that suitable methods to ensure it should be employed, such as division into smaller portions and cooling in a current of air provided by a fan.

(12) So far as practicable, left-over food should not be used again, but if it is to be used it should be stored promptly in the refrigerator or cold room.

(13) Made-up and other prepared foods should always be stored in the refrigerator or cold room, without delay, after preparation. To keep them at room temperature is dangerous.

(14) When food is stored in the refrigerator it should be placed so as to allow air circulation. Meat joints are preferably hung from hooks. The refrigerator should be kept clean and thoroughly cleaned out on the occasion of each defrosting.

(15) Detergents used in connection with utensils cleansing should be suitable for the conditions existing, and should be used in correct strength. The local authority should be consulted as to the appropriate detergents to use.

(16) VERMIN AND FLIES.

Rats and Mice. Infestation by rats and mice is dangerous, as they can spread infection to man. All practicable steps should be taken to eliminate this source of infection. It is essential :—

(*a*) To maintain the premises in thorough repair and to stop all ascertainable means of rodent access.

(*b*) To ensure that all food scraps are promptly removed and the premises maintained at a high level of cleanliness.

(*c*) To provide impervious receptacles with tightly-fitting covers for the storage of all foods attractive to rodents.

(*d*) To consult and seek the help of the local authority if rats or mice are found in substantial numbers.

Flies, Cockroaches and other Insects. The number of flies on the premises can be materially reduced by the rapid and efficient disposal of all food scraps and by using flyproof covers for food to the fullest possible extent. Manure or refuse piles or other materials serving for fly breeding near to the catering establishment should be reported to the local authority. The presence of cockroaches and other insects in numbers is often evidence of faulty fixing of plant and of inadequate hygienic practices. Thorough cleanliness and the provision of proper food containers are important preventive measures. The local authority should be consulted if the presence of these pests continues. When insecticides are used great care should be taken to prevent the contamination of food, equipment and utensils.

It is pointed out in the Report that no recommendations are made on the use of insecticides, as there appears to be no method which is suitable in every case.

(17) Measures to limit the infection of food from food handlers :—

(*a*) No person who is suffering from a discharging wound, sores on hands or arms, discharging ears or who is suffering from attacks of diarrhœa or vomiting should take part in the handling, preparation or serving of food in any catering establishment.

(*b*) Members of the staff should report to the proprietor or manager if they are suffering from any of the conditions specified in (*a*) above or from any other illness.

(*c*) The proprietor (or manager) of a catering establishment should take reasonable steps to become aware of the existence amongst his staff of any of the conditions specified in (*a*) above or of any other illness.

(*d*) The proprietor (or manager) of a catering establishment, as soon as he becomes aware that any member of his staff is suffering from any of the above specified conditions, should not permit such person to handle food until he (or she) is no longer suffering from the condition in question or permission has been given by the Medical Officer of Health.

(*e*) In the case of other illnesses, if there is a doubt whether the employee should continue work, the employee should be referred to his (or her) doctor pending resumption of work.

(*f*) Every applicant for employment should be informed of the possible risk from previous attacks of typhoid or paratyphoid fever and should be asked if he (or she) has previously suffered from one of these diseases. If he (or she) has so suffered, particulars should be reported to the Medical Officer of Health and the applicant not engaged until approval has been given by the Medical Officer of Health.

(18) Adherence to the hygienic requirements of this Code alone is not enough. It is of prime importance that all members of the staff (management and workers) should be imbued with and continually practise the principles of sound personal hygiene, and that they should take full advantage of any suitable courses of instruction which are available.

Separate suggestions are put forward in relation to *mobile vans and coffee stalls* * from which food is served. A specification of the hygienic requirements which the Working Party consider essential in such vehicles is as follows :

(1) The van should be constructed or lined with an easily-cleaned impervious material. Not less than three sides should be enclosed, and a sufficient part should be translucent to give adequate lighting.

(2) The floor should be so constructed as to be easily cleaned, and there should be no sunken portions.

(3) The van should carry a reasonable supply of wholesome water in a clean tank made of rustless material. For most vans 20 gallons would be a reasonable supply.

(4) Satisfactory means should be provided to give an adequate supply of hot water (170° F. minimum).

It is suggested that means for obtaining hot water could be part of the equipment of the van. As an alternative, boiling water could be carried in vacuum-pattern cylinders provided that water at the correct temperature is always available.

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(5) A two-compartment sink (or two separate sinks) should be provided for washing utensils, with drainage boards and discharge pipes and with hot and cold water taps over sinks.

(6) A suitable food store, protected from dust, should be provided.

(7) All food displayed for sale should be efficiently screened from contamination, preferably by using glass display cabinets.

(8) The top surfaces of all food preparation tables and counters should be covered with an easily cleaned impervious material.

(9) There should be a covered receptacle within the vehicle for refuse and waste.

(10) There should be an adequate supply of soap and towels.

The Working Party add that the vehicle and accessories should be cleansed daily, while light-coloured overalls should be worn by the operators.

Particular emphasis is laid on preventing the multiplication of organisms already present in food. This emphasis occurs throughout the Report. The Report also deals with the amendment of existing legislation, and the prevention of infection by human "carriers." The Working Party do not recommend a system of medical inspection at periodic intervals for catering staffs, but they do emphasise the importance of the control of food before it reaches catering establishments, the supervision of premises by local authorities together with uniformity of inspection and supervision, the use of detergents, mechanical methods of cleansing utensils, and educational measures directed towards the public and supervising officers. They do not recommend that catering establishments should be graded on the American principle, which is in some ways to be regretted when the results which might eventually accrue from such grading are borne in mind.

The Report contains a number of *main recommendations*,* which are set out below :

(1) All catering establishments should be required to register with the appropriate local authority.

It is suggested that all premises used for catering on the "appointed day" should be deemed to be registered following proper application to the local authority. Many premises are not inspected at the present time. Registration would assist in ensuring that inspection was adequate at all times. The prospect of loss of registration would be of considerable assistance in securing compliance with any of the requirements of the licensing authority.

(2) So far as is legally practicable provision should be made to enforce the Standard Code.

Certain premises would presumably be unable to comply in full with the Standard Code set out on pp. 482 to 484 of this Appendix. For this reason, it is suggested that the following types of premises should be partially exempt from the Code's provisions : small establishments of the hotel or boarding-house type, sports pavilions, public-houses and registered clubs, premises serving light refreshments, and small movable eating places.

(3) The Code for catering establishments of the mobile van and coffee-stall type should be made legally enforceable.

The recommendations relating to this type of catering establishment are set out on p. 484 of this Appendix.

(4) The Target Code should be regarded as an objective and all catering establishments should aim at complying with its requirements.

This Code is set out on pp. 485 to 488.

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(5) Provisions similar to those in section 13 of the Food and Drugs Act, 1938, and to those recommended in this Report for catering establishments ashore should be applied, so far as practicable, to passenger-carrying vessels.

(6) Section 13 of the Food and Drugs Act, 1938, should be extended to apply its provisions to catering establishments where meals are supplied free, or where meals are supplied but where, owing to some legal technicality, supply does not involve sale.

(7) The law should be amended so as to require the provisions of adequate lighting in places where food is prepared for sale.

(8) At some appropriate time paragraph (i) of section 13 (1) of the Food and Drugs Act, 1938, should be amended so as to remove any ambiguity in its interpretation in regard to the provision of hot and cold water for all purposes.

(9) So far as is constitutionally practicable, the same legal requirements, including registration, should be enforceable in respect of all catering establishments, by whatever body they have been provided or are operated, and where this is not constitutionally practicable the standards of hygiene practised should not be lower than those enforceable in the case of other catering establishments.

Examples of such premises are school central kitchens, factory canteens, and canteens belonging to the British Transport Commission and the National Coal Board. Difficulties in the inspection of such premises have occurred in the past. It is hoped that this recommendation will improve matters, and permit of their inspection. Kitchens on Crown property may still be immune, while the position of hospital kitchens needs clarification.

(10) Consideration should be given to the desirability of amending the Public Health (Infectious Diseases) Regulations, 1927, and the Infectious Diseases (London) Regulations, 1927, by extending their scope, so far as is practicable, and taking account of the problem of compensation, so that the provisions relating to enteric diseases (typhoid fever, paratyphoid fever and dysentery) become applicable to salmonella infections, staphylococcal food poisoning and other infections which may be spread by food.

In this connection, compensation of an employee for loss of earnings will call for attention.

(11) When the consolidation of the food laws of Scotland is undertaken, powers similar to those of sections 13, 15, 16 and 77 of the Food and Drugs Act, 1938, should be acquired.

(12) Consideration should be given to the desirability of applying section 17 of the Food and Drugs Act, 1938, to Scotland, or of adding "food poisoning" to the list of notifiable diseases in regulation 5 of the Public Health (Infectious Diseases) Regulations (Scotland), 1932, and to the Ninth Schedule of the Regulations.

(13) Provision should be made to adopt and extend a system for the assessment of actual and potential excretors of enteric infections along lines suggested.

The Working Party suggest that the assessment of the actual or potential excretor should be adopted as a routine practice. Hospitals should forward such assessment to the medical officer of health of the district in which the patient lives, so that he may take any statutory action considered necessary. It is suggested that patients, when discharged from hospital, should not only be clinically well but should be in a non-infective state.

(14) The Government should either utilise a suitable existing body or should set up a new standing committee :—

(*a*) To devise standard methods for estimating the efficiency of detergents under different conditions of utensil cleansing.

(*b*) To consider possible irritant action on the hands from detergents and to prescribe limits of alkalinity or other active components.

(*c*) To consider other possible toxic effects from detergents.

(*d*) To advise the appropriate departments as to the desirability of restricting the use of proprietary detergents in catering establishments to those which comply with specified efficiency tests under practical working conditions.

Approval of suitable detergents to be used for utensil washing should present little difficulty once those available have been tested. The Ministry of Agriculture and Fisheries already specify the proprietary brands of sodium hypochlorite solutions which may be used for the treatment of dairy utensils.

(15) Manufacturers of compound detergents should be required :—

(*a*) To specify the quantitative composition of the preparation as simply as possible.

(*b*) To give definite instructions on the necessary dilutions for effective detergent action under different conditions.

This would no doubt prevent waste and misuse of the proprietary detergents available.

(16) The attention of local authorities responsible for the supervision of catering establishments should be drawn to the requirements for mechanical dish washers and to the need for the supervision of their hygienic performance.

The Working Party quite rightly state that such machines should be both efficient and efficiently operated. They list a number of requirements for the effective washing of utensils by machine. These have already been mentioned in Chapter XXVII.

(17) The existing training in hygiene of personnel associated with the handling of food in any capacity in connection with catering should be extended and made a prominent and essential part of all courses.

(18) The British Travel and Holidays Association should take steps to promote the unqualified acceptance of the Standard Code (where it applies) by the catering industry.

It is suggested that each item of the Code (pp. 482 to 484) should be explained to the industry, stating why the items concerned have been included as a safety requirement and why none can be neglected without risk.

(19) An information centre should be set up by and on behalf of the catering industry.

Such a centre would be able to supply advice to caterers on hygienic problems associated with the catering trade, and the requirements with which the trade should comply. Not only could the premises and equipment be dealt with, methods could receive attention. Educational measures could also be discussed.

(20) Local authorities should continue to take an active part in promoting educational work connected with hygiene in catering.

If the Report is properly implemented by all concerned, there can be little doubt that substantial improvements should follow in relation to the present condition of catering establishments and the methods employed therein. It is to be hoped that the recommendations made will be fully considered by the responsible authorities, and put into operation with as little delay as possible.

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